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WADC TECHNICAL REPORT 52-267

INSTALLATION AND FLIGHT TEST OF DRAGLESS ANTENNAS FOR USE WITH VHF HOMING EQUIPMENT IN F-80, F-86, AND F-84 AIRCRAFT

SHERLA L. STUTZ
COMMUNICATION AND NAVIGATION LABORATORY

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WRIGHT AIR DEVELOPMENT CENTER

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August 1952

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Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

McGregor & Werner, Dayton, Ohio
150 - March, 1953

FOREWORD

This report was prepared by the Directorate of Laboratories in connection with RDO 101-108 (Development of VHF-UHF Homing Adapter) as authorized by Technical Instruction 2209-20. The investigations and tests described were made by members of the Communication and Navigation Laboratory of the Directorate of Laboratories under the direction of the Project Engineer, S. L. Stutz. This report is one of several reports being written on this project. Additional reports will be published as the data becomes available.

Included among those participating in the tests were pilots__________________ Lt. B. L. Griffin, Capt. J. K. Stuart, Lt. R. E. Chase, Capt. W. A. Grusy, Capt. H. W. McQuown, Capt. Ed Hoagland and civilian engineer Mr. R. E. Kester.

ABSTRACT

An investigation of the chosen antenna and location including installation and flight test data of dragless antennas for VHF Homing Equipment in the F-80, F-86, and F-84 jet aircraft. The report includes samples of radiation patterns of modeled antennas on modeled aircraft, artist sketches of flight tests, pictures of aircraft after installation of antennas and equipment, artists profile sketches of equipment installed and brief results of the various flight tests conducted on the operative equipment. From the study and tests it is concluded that the antennas and equipment so installed result in a satisfactory and usable VHF (Flush Mounted) homing antenna and equipment installation for the F-80, F-86, and F-84 airplanes.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

George H. [illegible] Jr.

for C. U. BROMBACH,
Colonel USAF.
Chief, Communication & Navigation Laboratory
Directorate of Laboratories.

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INTRODUCTION

During World War II, a simple, right and left sensing, aural indicating, homing adapter was developed by the then Engineering Division of AMC (WPAFB) for installation and use on fighter and some long-range bomber aircraft to enable the aircraft to find the landing strips with the least possible delay and expenditure of fuel. The equipment also permitted the cover aircraft to find and keep in range of the convoyed aircraft. This simple homing adapter was known as "Homing Adapter AN/ARA-8 and 8A".

Subsequent to World War II the "Adapter" has enjoyed fairly widespread use in Air Sea Rescue Work, certain "mock missile" tests and "hold-off" action by FEAF.

Some portions of this same equipment were used in obtaining the test results reported here.

Previous tests of this Homing Adapter equipment have been performed on the F-51, P-38, F-82 and numerous heavier aircraft so that pattern wise and functionally the minimum pattern requirements for satisfactory homing have been fairly definitely established. All of these previous installations, with one exception, included in the installation a pair or two pairs of stock AN/ARA-8 streamlined stub antennas (AS148) mounted externally to the skin of the aircraft. However, the speeds attained by the F-80, F-86 and F-84 aircraft precludes the use of antennas having only a small amount of aerodynamic drag so that the flush mounting of an efficient antenna in a suitable, structural and radiation patternwise location, on the aircraft, is a problem. Even though the techniques used in the designing of the antennas is not to be detailed in this report the following describes the approximate approach used:

The contractor for the F-80 aircraft was consulted to discuss likely locations for the antenna in the aircraft that would allow sufficient depth below the skin to permit the installation of an efficient antenna configuration and not physically interfere with the other equipment scheduled for installation or the structural integrity of the aircraft.

SECTION I

DATA

GENERAL REQUIREMENTS The project was initiated to supply installation information and test results to the interested services (Air Sea Rescue Service, Far Eastern Air Force, some units of TAC and SAC and some Missile Test Groups of WADC).

VHF, lobe switched, type homing adapter equipment will continue to be used on certain USAF and other service aircraft during the (interim period) change from VHF command equipment to UHF command equipment.

ELECTRICAL REQUIREMENTS The electrical requirements are such that the adapter installation shall function satisfactorily with Radio Set AN/ARC-3 (VHF Command) when it is tuned to operate in the frequency band of 120 mcs to 140 mcs, and shall produce the required aural code information in the pilot's headset.

Patternwise; the antennas shall be installed and phased in such a manner as to produce two overlapping cardioid radiation patterns, so placed in space with respect to each other and the aircraft as to produce a cross-over or pattern intersection line fore and aft thru the aircraft. This cross-over line is to be coincident with a fore and aft through the aircraft fuselage.

TACTICAL REQUIREMENTS The tactical requirements are that the adapter installation shall furnish the desired code information to the pilot's headset when the airplane is flying in any direction, toward or away from the ground station, and in any flight attitude between 0^{o} and 15^{o} bank or climb, or both. The adapter shall continue to furnish the required information as long as it is operating throughout the homing run. The radiation and reception pattern shall be such that the pilot will hear the code character "D" in the headset when the ground or airborne station is to the left of the aircraft, and the character "U" when the target station is to the right of the aircraft. When the aircraft is heading directly away from the station, a continuous tone shall be heard indicating that the aircraft is headed either toward or away from the target station. A maximum of 20^{o} in azimuth ahead of the aircraft and approximately 15^{o} in azimuth to the rear of the aircraft shall determine the limits of the "on course" and "tail course", respectively. Homing Run Sketch, figure 1, depicts a slightly exaggerated "homing run" with a successful installation showing the approximate placement and shape of a satisfactory radiation pattern about an aircraft in flight. It is to be noted that in most Homing Adapter AN/ARA-8A installations employing flush mounted antennas the width of the "on course" and "tail course" are functions of the operating frequency in megacycles; that is to say, when the operating frequency is in the vicinity of 120 mc it is not unusual for the "on course" to be 5° wide at the limit of the range (90 mi at 10,000 feet altitude, naut.) from the target station, while at the operating frequency at 140 mc the "on course" width is approximately 20° wide at the limit of the range. The Pattern Investigation Sketch, Figure 2, is an artist's conception of a pattern investigation test. The usual procedure is that the target station operator transmits a CW, unmodulated carrier while the pilot turns on the VHF command receiver and homing adapter, and listens and records the code characters heard as he turns a flat circle about a point remote from the ground station. The pilot also determines the position "in the circle" and "width" of the "on course", and the "tail course" during the execution of the flat (0° bank) circle. The pilot also determines the position, width and number of "false on courses" that may be present in the circle. If the code character portions of the patterns and the "on course" and "tail course" areas are properly located, a homing run is usually conducted to determine the accuracy of the homing available on the tested frequency.

NOTE: A "false on course" is aurally identical with a true "on course" or "tail course" except for location (degrees) with respect to dead ahead of the aircraft and the fact that the turn right and left code characters "U" and "D" are on the reverse sides of the tone area (in the most forward of the two false courses), which determines a pattern intersection line ("course"). See Fig. 3. In other words if the pilot is turning a right turn with the signal arriving from the right hand side of the aircraft and the code character suddenly changes back to a "U" character a second "false on course" has been turned through. All "false on courses" appear in pairs and are usually of equal strength (signal amplitude), width (degrees, azimuth) and may or may not appear very near each other, in azimuth. The "false on courses" that appear very near each other usually occur near the true "on course" or "tail course" and result from reflections from portions of the aircraft very near the antenna and aircraft fuselage. Narrow in azimuth "false on courses" such as these are of little consequence since with a properly adjusted automatic gain control (AGC) they usually go unnoticed during tactical application of the equipment. "False on courses" that lie on either side of a very large sector (degrees, azimuth) of the radiation pattern, having the wrong code character, cause the most confusion to the pilot. In these instances the pattern should be studied very carefully and possibly on more than occasion to permit the proper interpretation of its configuration. "False on courses" of this type result from improper installation or faulty equipment, and occasionally from reflections from parts of the aircraft well removed from the homing antenna panel or from reflecting objects apart from the aircraft; other aircraft, mountains, etc. A pattern having this type of "false on course" or "courses" in its makeup should not be tolerated or used. The antenna installation cannot usually be adjusted to compensate for reflections from elements well removed from the aircraft structure.

ANTENNA FORM FACTOR Since 1946 the increased speeds of the then current and near-future aircraft demanded that all VHF Stub type antennas be faired-in or made flush with the skin of the aircraft to avoid the resulting increased aerodynamic loads. The first full scale, flying, dragless homing antennas for VHF frequencies were designed, installed and test flown in an F-82 twin-mustang. The antenna installed in the F-80, F-82 and F-84, and eventually the F-86 are pictured in Figures 4, 5, 6, 7 and 8. The results of these tests indicated that antennas were sufficiently efficient and dynamically sound to be seriously considered as prototypes for future, similar installations. These considerations were subsequently proven to be correct as shown by the flight test data of the F-80, F-86 and F-84 installations pictured and described in this report. In addition it is often necessary for the antenna to perform satisfactorily, when located in a position on the aircraft that does not provide a mounting depth below the skin of greater than 3 or 4 inches. The aperture area in the aircraft skin surrounding the radiating element of the antenna should be approximately 400 square inches for these frequencies. This aperture should be as square as possible, i.e., less that 3/1.- length/width. The antenna panels should be structurally designed to withstand rapidly changing atmospheric pressures since it is sometimes necessary to install them in a location on the aircraft that is subjected to such pressures. It has been found necessary to design the antenna panel to withstand the effects of the above forces which usually occur simultaneously with the deleterious effect of extreme low temperatures (High Altitude).

See Fig. 5 and 9. Fig. 5, pictures a good antenna panel structural design. Fig. 9 pictures results of exposure to a high speed and low temperature conditions on a make shift panel design. The surface impregnant cracked and blew away as a result of the rapid pressure changes that occurred while at the low temperature. The antenna should be designed for exposure to long periods (several minutes time) of bombardment from rain or ice pellets traveling at rates of speed in the order of 13 to 1400 feet per second. The antenna system is, wherever possible, designed to be placed in the aircraft skin in other than symetrical locations (centerline of top and/or bottom of fuselage) to eliminate the necessity for cutting into any of the main longerons, formers or bulkheads. In the design of the antenna panel the physical shape and size is adjusted as nearly as possible to the configuration and dimensions of the section of the aircraft surface into which it is to be installed. The antenna panel is, wherever possible, placed in a section of the aircraft surface that is unpressurized and that has approximately equal normal pressures both inside and outside, while in flight. If the pattern studies of the particular aircraft will permit and the opportunity presents itself the panels are designed to replace existing access or inspection doors. This procedure permits ready fabrication, installation, replacement and/or modification, when and if the aircraft is already in production status. Such an antenna is pictured in Figures 10, 11, 12 and 13. To counteract forces and effects of low temperatures and rapidly changing pressures the antenna panel is designed of "void free" laminated, structural plastic incorporating reinforcing ribs, and impregnated with the proper and not excessive amount of low loss (electrical) binder plastic. The antenna panel is (in addition) coated with an outer skin of vinyl plastic or rubber which increases its resistance to rain and ice particle errosion. Due to the location and size of various other aircraft components that may be installed near the antenna panel it is sometimes necessary to use metallic backing thus forming a cavity behind the panel to reduce the mutual coupling between the panels and other aircraft equipment or stray (RF) fields. The resulting cavity should be an appreciable portion of a wavelength deep whenever possible so as not to result in an unfavorable antenna impedence and/or lowered "Q". The employment of a cavity behind the antenna panel makes it possible to achieve a balance between the elements of the antenna system more easily than without.

SECTION II

FLIGHT TESTS

BACKGROUND.- During the summer of 1945 some preliminary flush mountable VHF Homing Antenna configurations were designed and tested on the Laborator's roof-top shielded room. The tests included determination of requisite cavity size, spacing of elements (mutual coupling), electrical length of radiator element, overall efficiency and approximate radiation resistance in terms of VSWR. A large portion of this work was of necessity "cut and try". After several months of spasmodic work approximate values for the above parameters were obtained.

FLIGHT SUMMARY DATA NO. 1.- A flyable antenna system manufactured in the laboratory and installed in the flying F-80A pictured in Fig. 4. A few preliminary flight tests were conducted on the aircraft for pilot familiarization. The equipment was then transferred to another F-80A model and a series of planned flight tests were conducted. During the twenty-two flights, of testing the antenna system, it was learned that the patterns were satisfactory providing the aircraft attitude did not exceed the following:

a. Bank or climb (dive) in excess of 15°.

b. Range of 90 naut. miles at an altitude of 10,000 ft.

NOTE: These test flights showed that a pilot familiar with the equipment and installation could make accurate homing runs from high altitude and high speed using the following technique.- Make high altitude pass over ground target following homing course and as station is passed (rapidly fluctuating signal levels occurring in the headset indicates station passage) continue beyond station about 5 - 10 miles, depending on altitude and speed, make a 180° turn around and descend to a new altitude (minimum safe), check for right and left "turn" indication ("D" & "U") and fly "on course" into target. If tactically permissible a minimum safe speed of approach will assure a much more accurate pin-pointing of the target and usually results in direct observation of the target (less than 5° from dead ahead).

FLIGHT SUMMARY NO. 2.- In mid 1946 the investigation of a flush-mounted homing antenna system for the F-82 aircraft was started. This antenna system consisted of two flush mounted stub antennas, located, one in each outboard vertical stabilizer fin skin. The area behind the antennas was "boxed in" so as to form sides of a cavity, the bottom or back of the cavity then being the inboard skin of the respective vertical fins, see Artist's sketch Fig. 6 and picture Fig. 7 of F-82 installation. The radiating stub antenna was molded into a sheet of structural plastic which formed the front of the "boxed in" area in each stabilizer. Fig. 14 pictures the F-82 antenna panel ready for installation. The prototype system was installed and tested in a static test model F-82 empennage with a target transmitter (in flying aircraft) moving around the grounded empennage installation. Results from these tests indicated that the system provided good range (sensitivity) and was apparently accurate. The installation was transferred intact to a flying aircraft (F-82) and numerous flight tests were conducted during 1947. Most of these tests were run concurrently with the F-80A tests. The tests revealed that the F-82 installation was less sensitive to operating frequency and the "on course" width (degrees in azimuth) was consistently sharper (2 to 5 degrees). The F-80A installation homed satisfactorily from 120 mcs to 140 mcs or 15.4% bandwidth, while the F-82 installation homed successfully from 115 mcs through 145 mcs or about 23.1% bandwidth. The location of the "on course" ahead of the aircraft did not shift with a change in operating frequency in the case of the F-82 installation, as readily as it did with the F-80A installation. All of the above mentioned F-82 advantages are attributable, in large part, to the lack of mutual coupling between the antenna elements composing the system. As can be seen by referring to artist's sketch, Fig. 6, the antenna stubs are fairly well shielded and physically spaced from each other and were not conductively coupled in any way, whereas in the F-80A installation the reverse was true.

From previous study of the model radiation patterns of homing antennas located in the empennage area of the P-61 and F-82 aircraft it was noted that unless the antennas were designed to look away from the aircraft their resulting energy fields would not permit satisfactory homing. If any appreciable amount of energy crosses the discontinuous ground plane formed by the fuselage booms and stabilizers of these aircraft numerous false courses result in the right and left hand lobes of the composite pattern. Ground and flight tests of the P-61 and F-82 verified the approximate reliability of these patterns.

FLIGHT SUMMARY NO. 3.- During August 1951 the antenna configuration, shown in artist's sketch, Fig. 8, and photographs Figs. 15 and 16, installed in the F-86A aircraft was subjected to 34 hours of flight testing. As can be seen from the sketch and photograph the antenna system used is quite similar to the F-80A and F-80B installations, except for the fact that due to the sweep-back of the vertical stabilizer the radiating elements of the system are now 35° removed from vertical orientation. As a result of this sweep-back of the radiating elements, it was suspected that the radiation field distribution about the aircraft may be adversely affected. Other possibly adverse, contributing factors to the resulting pattern were the slight amount of cross-polarization present and the increased proximity of the wing tips to the antenna system due to their sweep-back. An inspection of the model antenna radiation patterns showed the presence of an increased amount of horizontal polarization in comparison to the F-80A and B, model patterns.

The F-86 aircraft model patterns show the presence of a broad "on course" in most planes of energy; at all three test frequencies. Some signal depression in the 140° and 220° area is indicated also by these model patterns. The sensitivity of the antenna system at or near the dead ahead position does not build up rapidly enough, per unit of aircraft turn, to give a good pattern cross-over (intersection) resulting in a broad "on course" ahead of the aircraft.

1. The flight test results, to a large degree, corroborated the model pattern data in that some signal level deterioration was noted when the direction to the target station was in the port-aft and starboard-aft sectors of the patterns.

2. In directions ahead of the aircraft the "on course" location would change during the executing of a bank or climb/dive maneuver when in excess of about 7°. The amount of "on course" shift during this time depended somewhat, on the operating frequency.

3. Ahead of the aircraft, at or near the "on course" sector, the homing sense was sufficiently accurate when the ship was held steady, less than 5° of bank, or climb, or dive, to provide satisfactory homing runs.

4. The "on course", was not as broad as was indicated by the model pattern data if the aircraft is held in level flight during the homing run. At high rates of speed the "on course" was too sharp (near the target station) to pin-point the target (less than 500 ft). Apparently, due to the antenna's increased sensitivity to horizontal polarization in this installation, increased reflection interference was experienced from ground base elements, i.e., large high-tension lines and cross-country telephone trunk lines, etc. From these flights it was learned that if the pilot was familiar with the minor eccentricities of the antenna pattern, accurate homing runs could be accomplished.

FLIGHT SUMMARY NO. 4.- From January 1952 to May 1952 seventeen flight hours were expended testing the homing antenna panels shown in the pictures, Figs. 10, 11, 12 and 13. These antenna panels were installed and tests were conducted on the F-86A aircraft. Three basic types of antennas were tested behind these plastic panels installed in the "engine access door" area. The first several flight test hours were spent testing a much abbreviated one quarter wavelength stub type radiator. This antenna produced reasonably good homing patterns, however, the range (efficiency of radiation) was reduced some and the "on course" was removed from ahead of the aircraft so that the aircraft on homing run would approach the station over a curved path. At maximum approach speeds the pilot, due to human reaction time, was unable to maneuver the aircraft over the target station. During one flight test a form of folded (less than) one quarter wavelength stub antenna was checked. Even though the apparent sensitivity of the element was much improved over the previous stub antenna homing was not possible due to the severe lobing in the composite homing pattern. In flying a pattern investigation circle it was found that the turn right - turn left information was received successive by every 10^{o} around the 360^{o} circle. This pattern eccentricity was due largely to the great spacing between the fed half and the grounded or return half of the folded stub radiator. A third antenna configuration was tested during these flight tests. The antenna tested was a (less than) one quarter wavelength stub antenna inductively and capacitively top loaded so that the resonant frequency was very near the center test frequency. The top loading section was, electrically, a form of unbalanced open wire transmission line. The frequencies tested extended from 127 to 149 mcs. Using this last antenna configuration the homing patterns were found to be very good and homing runs were quite accurate from a good distance. Ranges of 100 mile at 12,000 ft. were repeatedly attained. The test pilot stated that this installation was preferable to either of the other types of antennas located and tested in that section of the aircraft and also preferable to the vertical stabilizer panel installation shown by Figs. 8, 15 and 16. NOTE: To the present time corroborating pattern studies have not been made on this antenna location.

FLIGHT SUMMARY DATA NO. 5.- Figs. 17 and 18 show the installation of flush mounted VHF Homing Antennas in the F-84G aircraft for special service use. This installation was designed, installed and flight tested during May and June 1952. The flight tests indicated that the antenna installation in the fixed portion of the canopy (fig. 18), using frequencies between 129.0 mcs and 140 mcs, homed accurately from 275 miles at 29,000 ft. or 100 miles at 10,000 ft. No indication of the presence of false courses were noted during any of the tests while aircraft was in less than 10^{0} bank. The only apparent depreciation of the pattern on the tested frequencies was very narrow 6 db signal depression at about 7 o'clock and again at 5 o'clock, likely caused by something in the aft canopy area shadowing the radiating elements. Some shadowing by the airplane fuselage and wings was noted when the signal is arriving from the rear and below the horizon. Since this direction is relatively unused for homing the deficiency is merely noted. Figs.19 and 20 picture the second installation having the large interfering metal boxes between the antennas. This installation was found to be very unsatisfactory for homing and inferior by comparison to the "just described" installation. The time schedules involved did not permit the usual model pattern studies so that no model patterns were available for study or corroboration of the full scale flight test results described in this report. NOTE: Artist's sketches of the antenna and RF circuitry of the most satisfactory installation on the F-86A and the F-84G are shown by Figures 10 and 17 respectively.

SECTION III

CONCLUSIONS

1. The installation of VHF Homing Antennas in the F-80 aircraft as described is functionally satisfactory providing the aircraft attitude does not exceed a bank or climb (dive) or more than 15° and an air-to-ground distance in excess of 90 nautical miles at 10,000 ft. altitude.

2. The F-82 VHF Homing antenna installation is functionally satisfactory over a range of 80 nautical miles air-to-ground (10,000 ft.) and was much less sensitive to bank and climb angle and more sharp of "on course" regardless of operating frequency. The effective bandwidth of this installation was 23.1% while the F-80 installation was only 15.4%.

3. The F-86A (vertical stabilizer) VHF Homing antenna installation was functionally satisfactory to the approximate same degree as the F-80A installation except that range was slightly improved. Some additional interference was experienced from ground based elements (high tension lines and cross country telephone trunk lines), than was experienced with the F-80 installation. This installation, if used, would require more pilot familiarization than either the F-80 or F-82 installations.

4. The F-86A (fuselage) VHF Homing Antenna installation was functionally much more reliable and superior in performance to either of the three previously described installations (F-80, F-82 and F-86). Flight test results showed that good homing runs could be conducted in the frequency range of 129 to 149 mcs most accurately from 100 nautical miles air-to-ground from 12,000 feet.

5. The F-84G (windshield) VHF Homing antenna installation was functionally very satisfactory in the frequency band of 129 to 140 mcs and pattern-wise superior to all previous installations including the second F-86 installation. However, under certain tactical conditions (high speed approach) the "on course" was too narrow to fly with ease. This minor deficiency can be readily overcome by reducing the airspeed during final approach.

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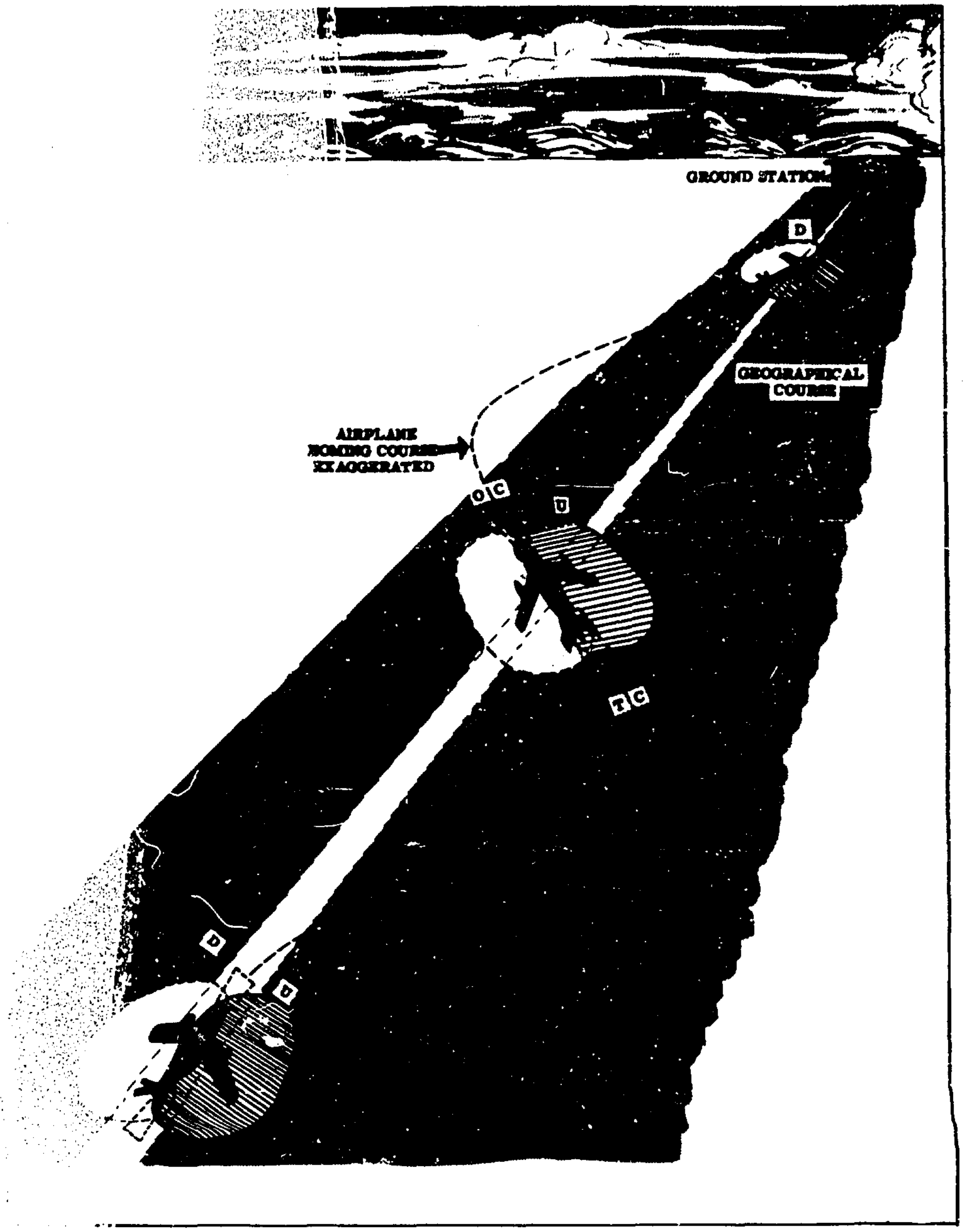
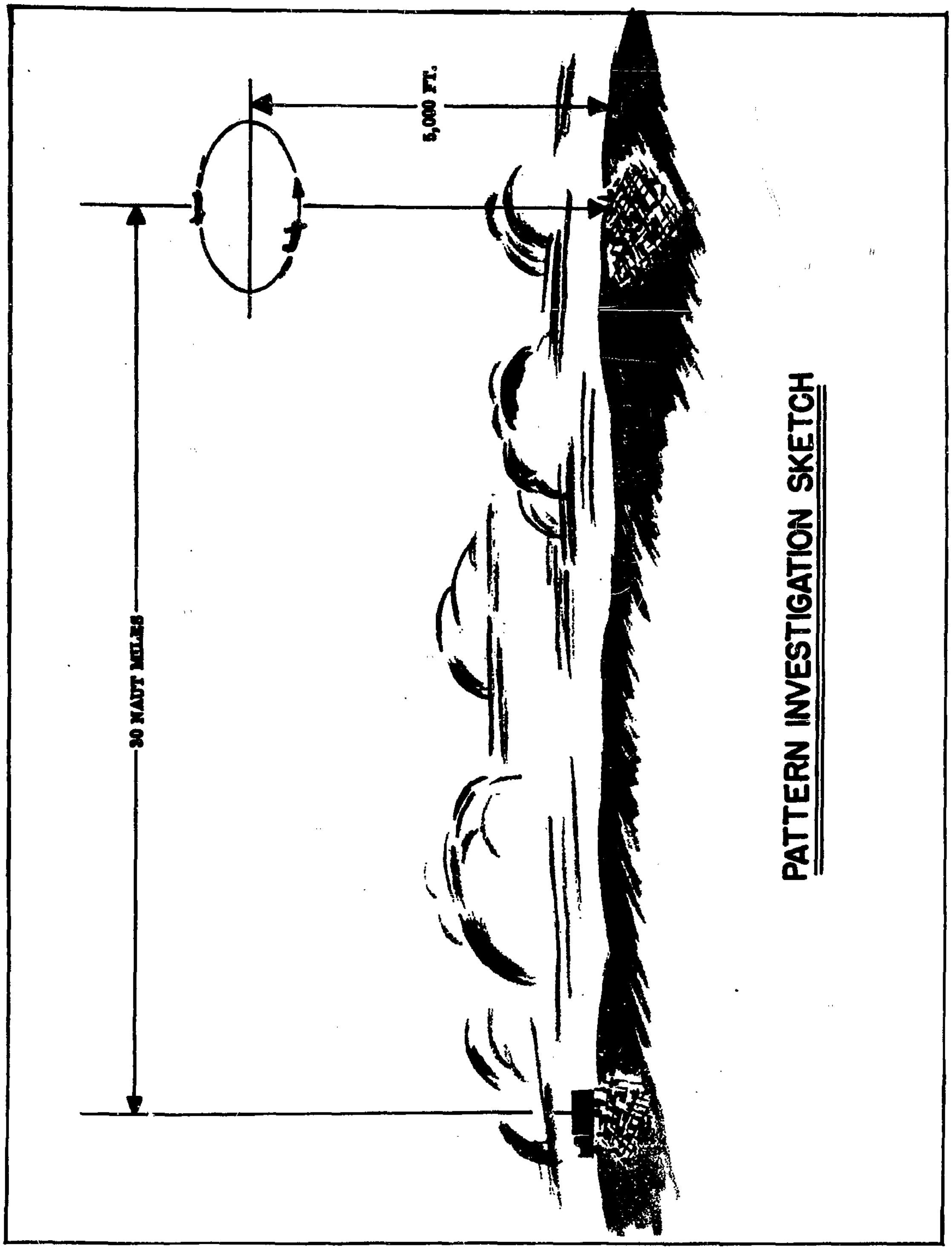
APPENDIX 1

ILLUSTRATIONS

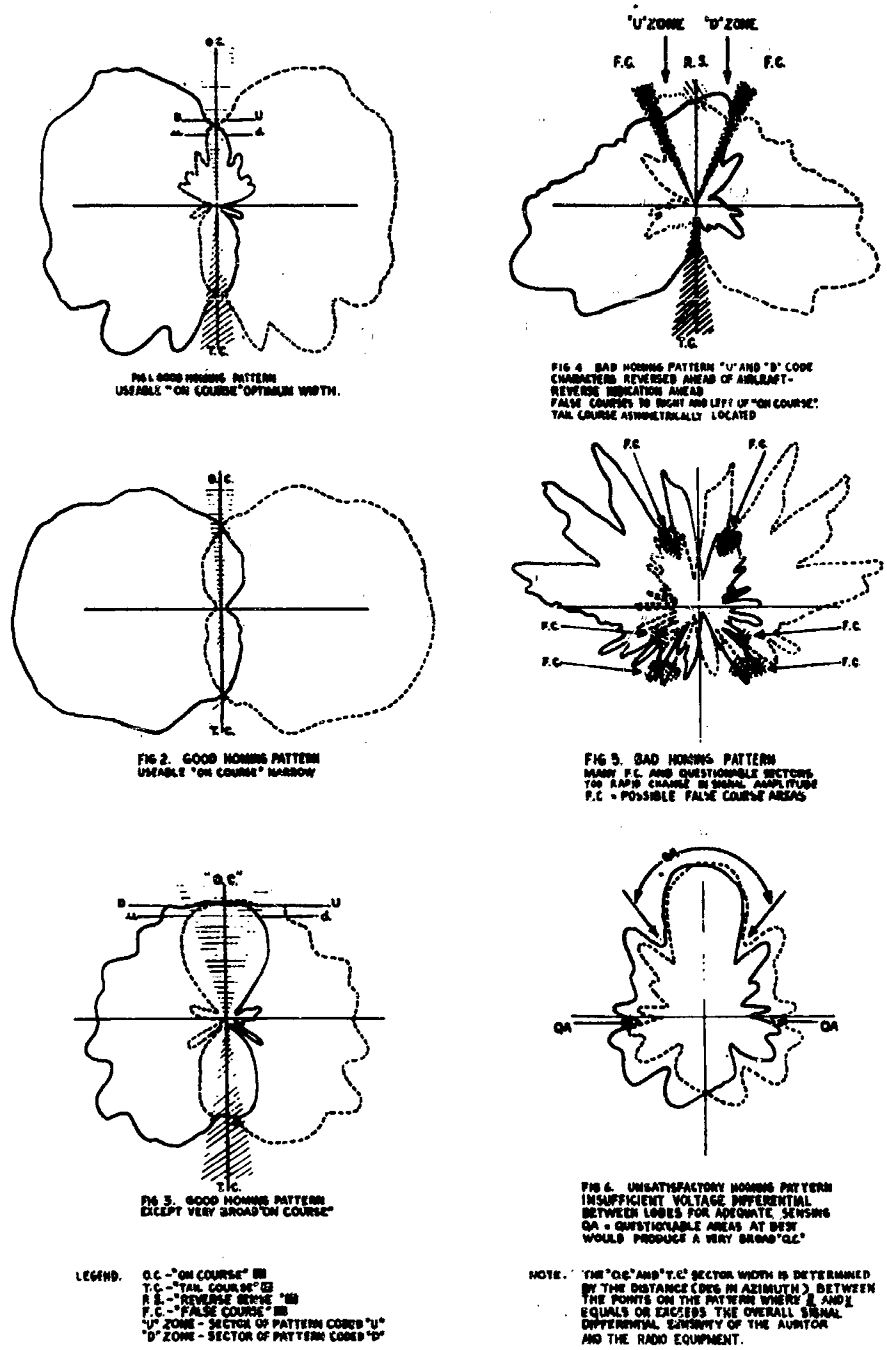


Homing Run Sketch

Fig. 1



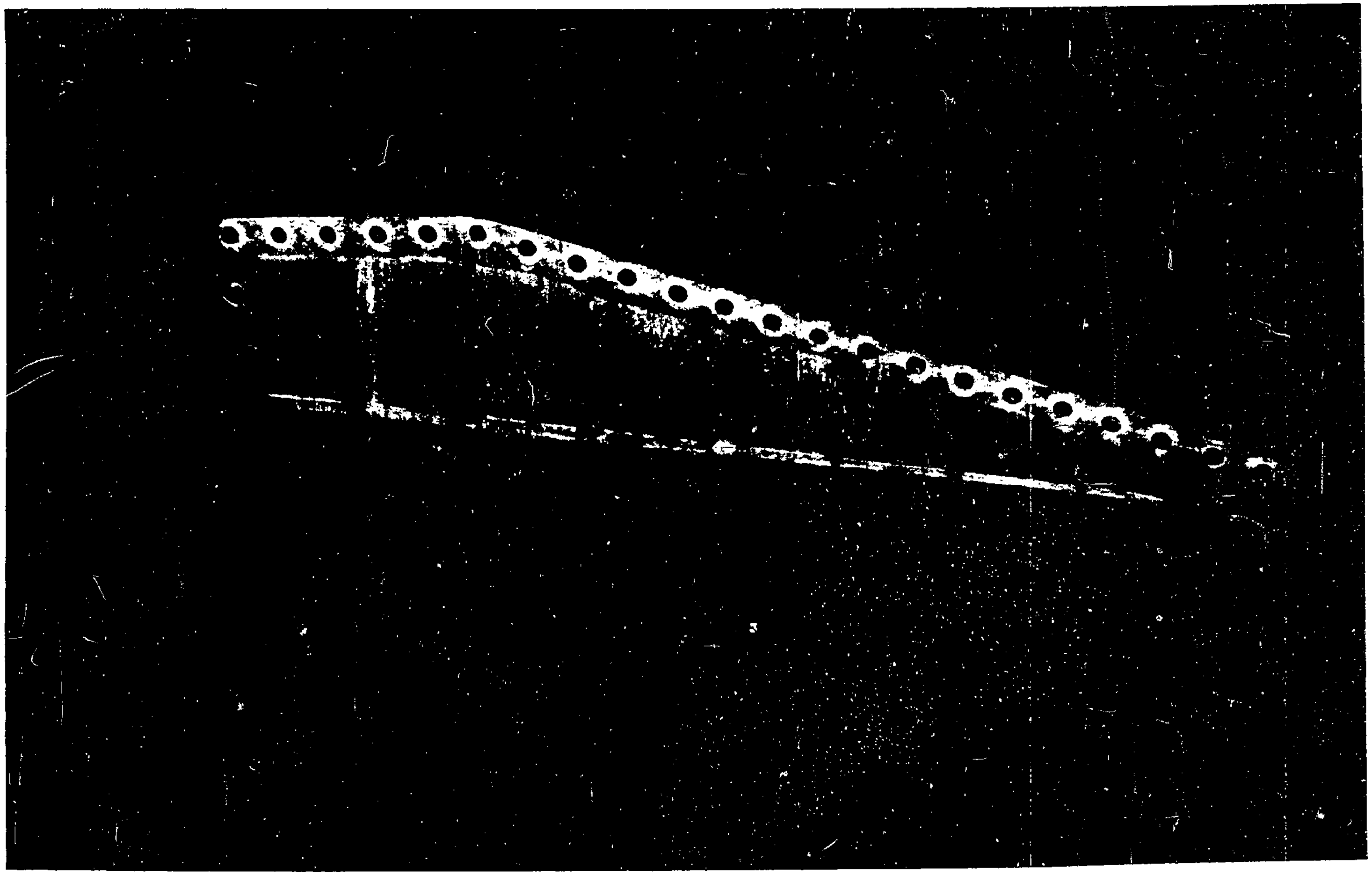
Pattern Investigation Sketch
Fig. 2



Typical Pattern Sketch
Fig. 3.

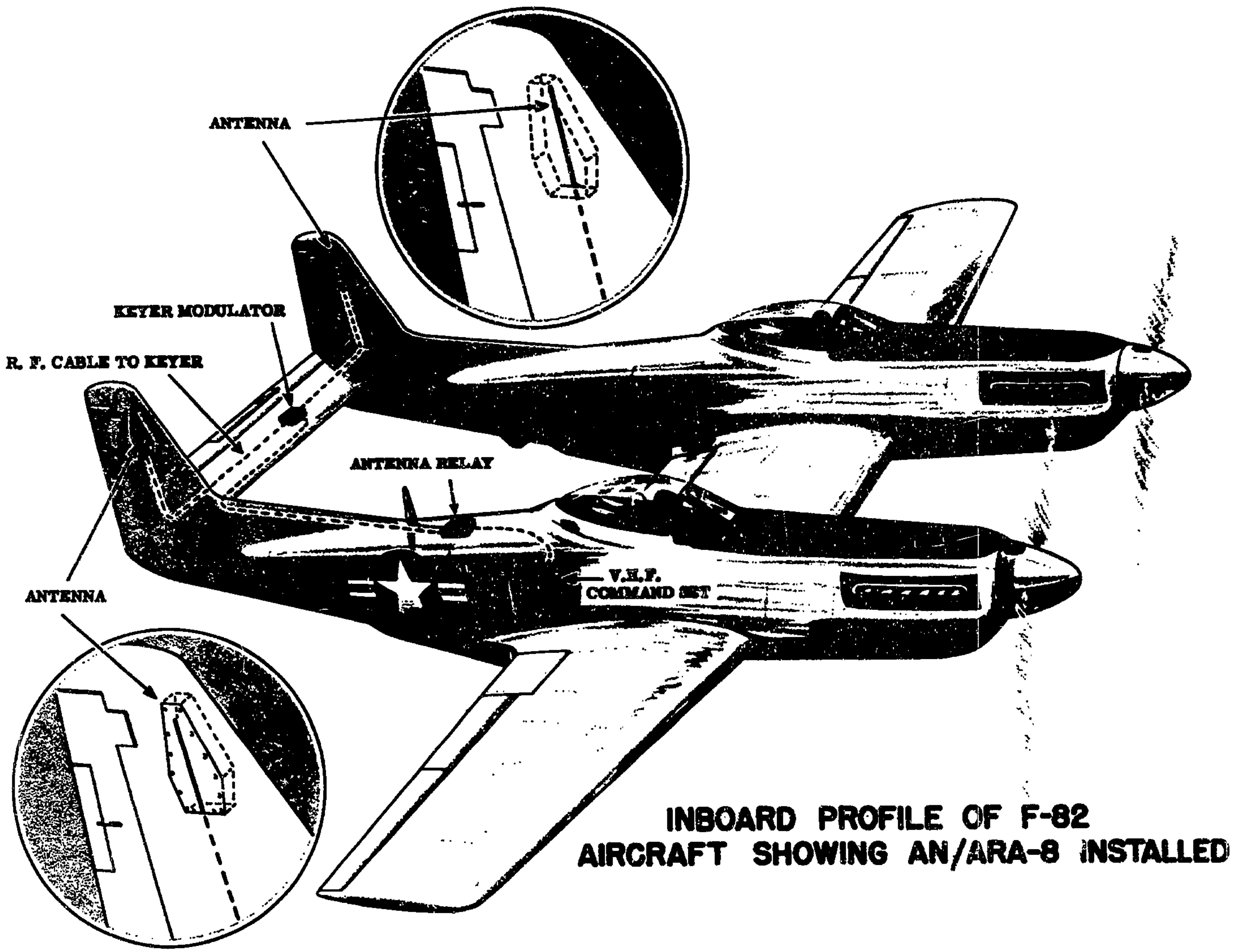
FLUSH-MOUNTED ANTENNAS FOR RADIO SET AN/ARC-3 AND HOMING ADAPTER AN/ARA-8
IN F-80 AIRPLANE 5337

Fig. 4



VHF HOMING ANTENNA FOR F-80 TYPE AIRCRAFT (VIEW OF INSIDE PANEL SURFACE); USED WITH HOMING ADAPTER AN/ARA-8. PROCURED FROM LOCKHEED AIRCRAFT CORP. AS PART OF THE VERTICAL STABILIZER IN F-80 TYPE AIRCRAFT.

Fig. 5

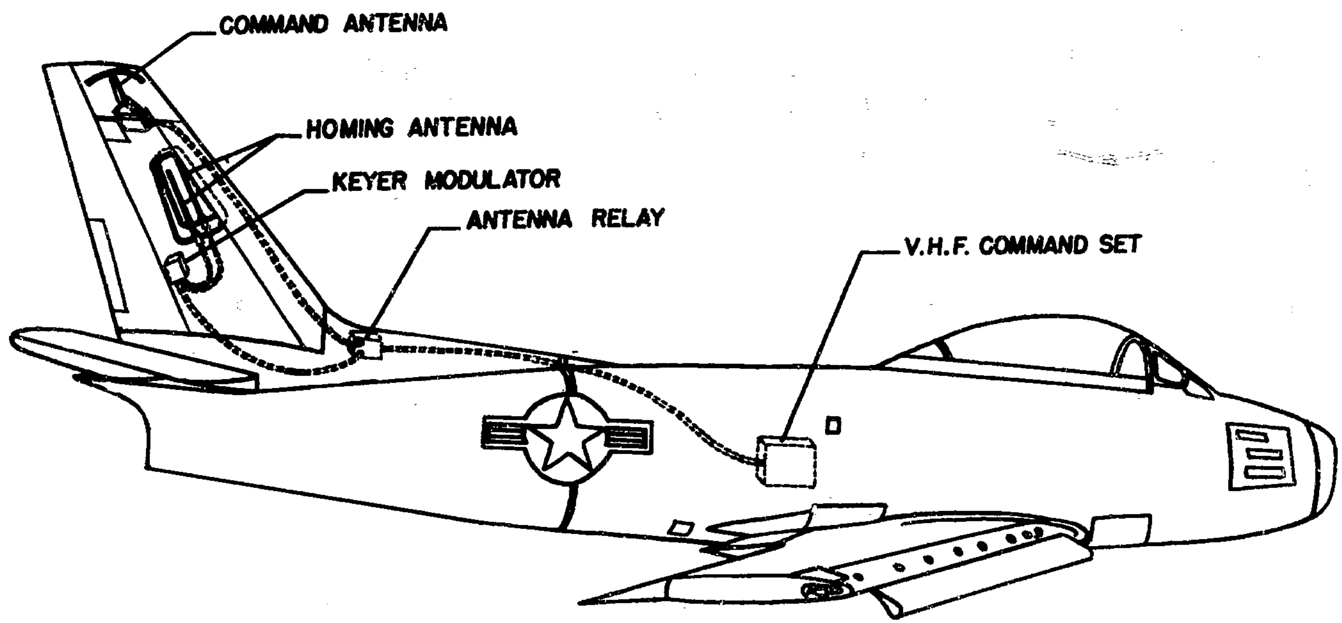


Inboard Profile F-82 Installation

Fig. 6

INSTALLATION OF DRAGLESS VHF HOMING ANTENNA IN F-82 AIRPLANE.
USED WITH HOMING ADAPTER AN/ARA-8A.
NOTE: THIS ANTENNA IS UTILIZED WHEN HOMING ADAPTER AN/ARA-8A IS USED WITH RADIO SET AN/ARC-3.

Fig. 7



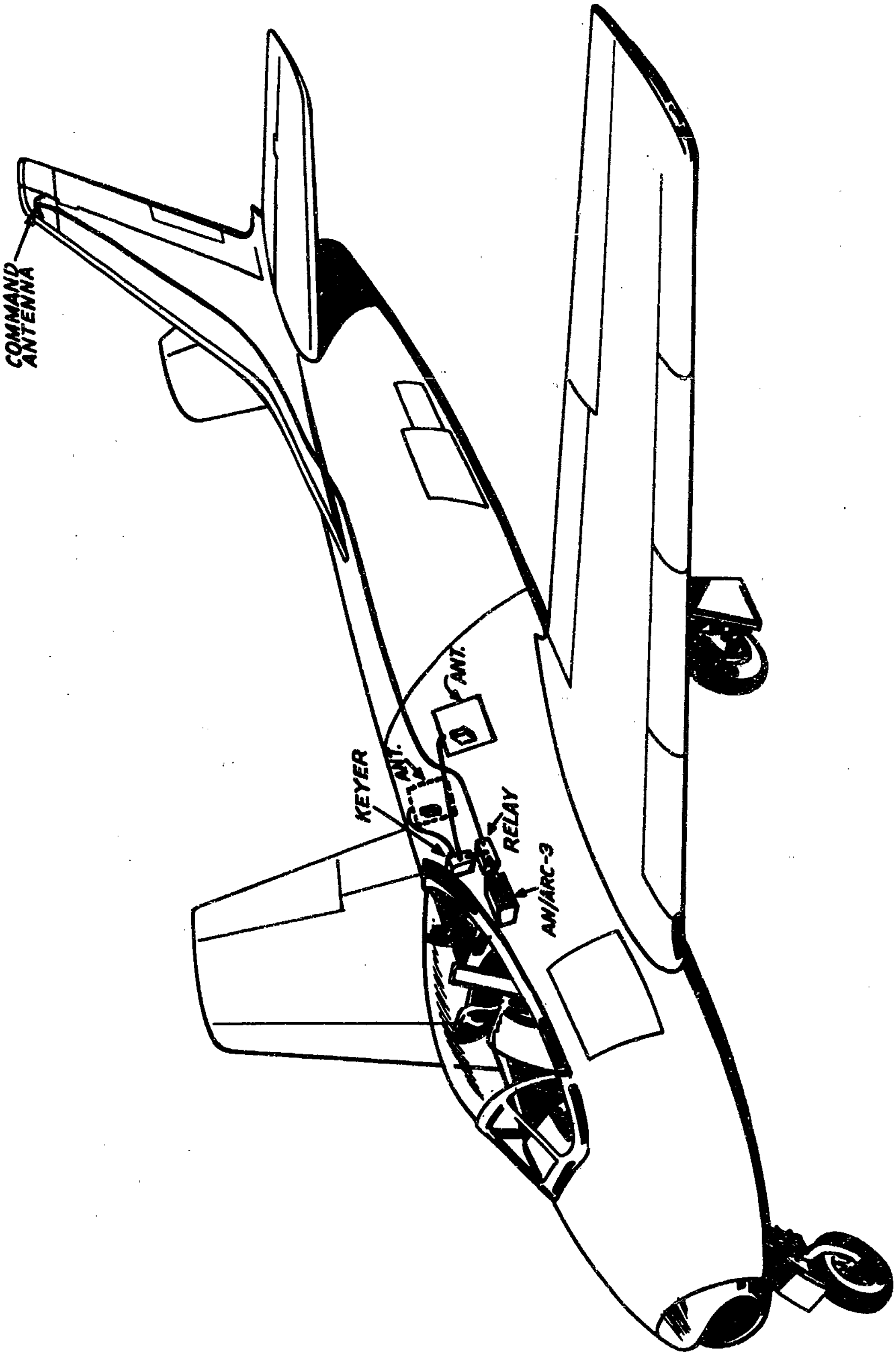
INBOARD PROFILE OF F—86 AIRCRAFT
SHOWING AN/ARA—8A INSTALLED
INCLUDING FLUSH MOUNTED ANTENNA SYSTEM

Inboard Profile F-86 Homing Installation

Fig. 8

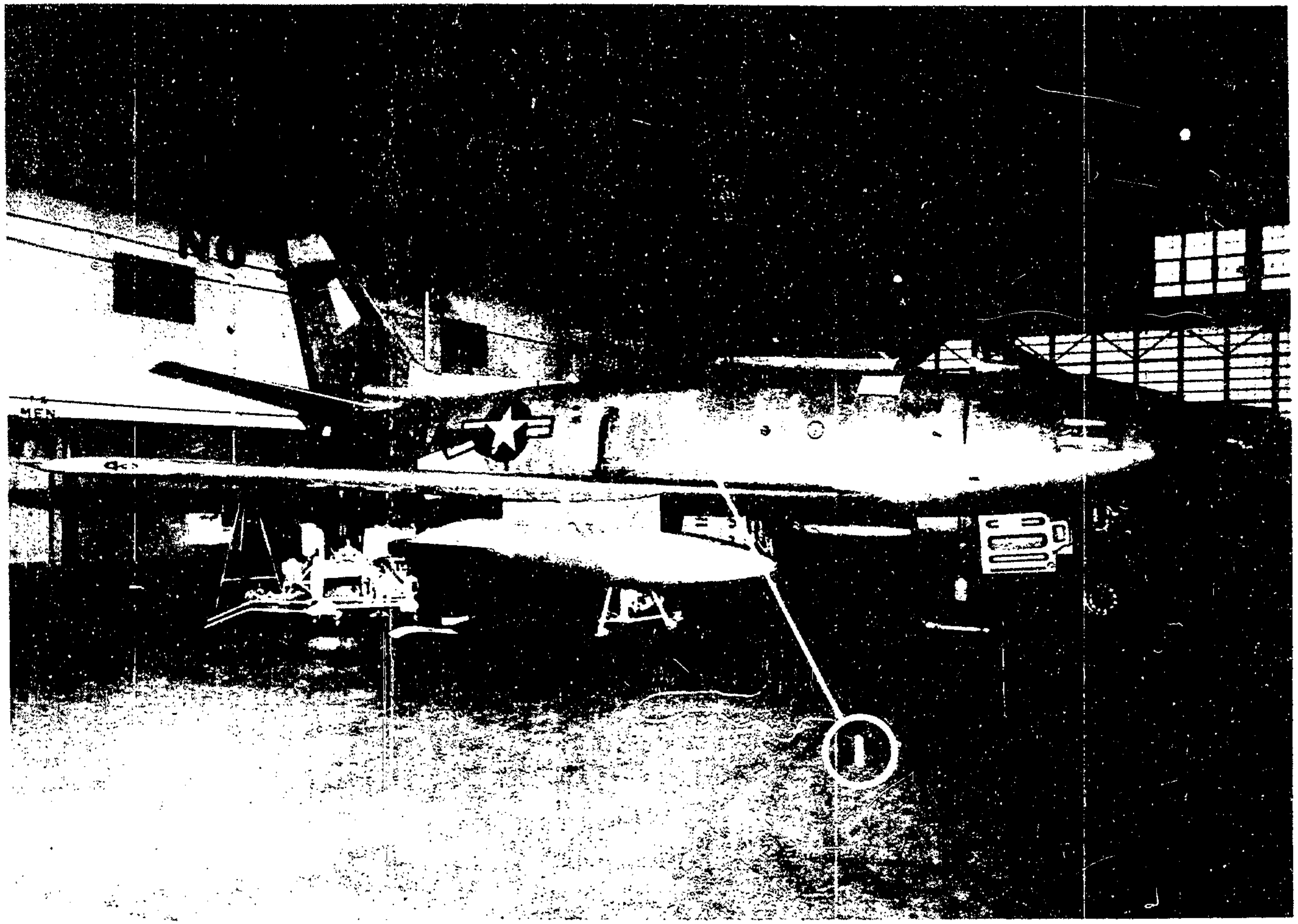
FLUSH-MOUNTED ANTENNA PANEL FOR HOMING ADAPTER AN/ARA-8.
IN F-80 AIRPLANE, SERIAL NO.5337.

Fig. 9



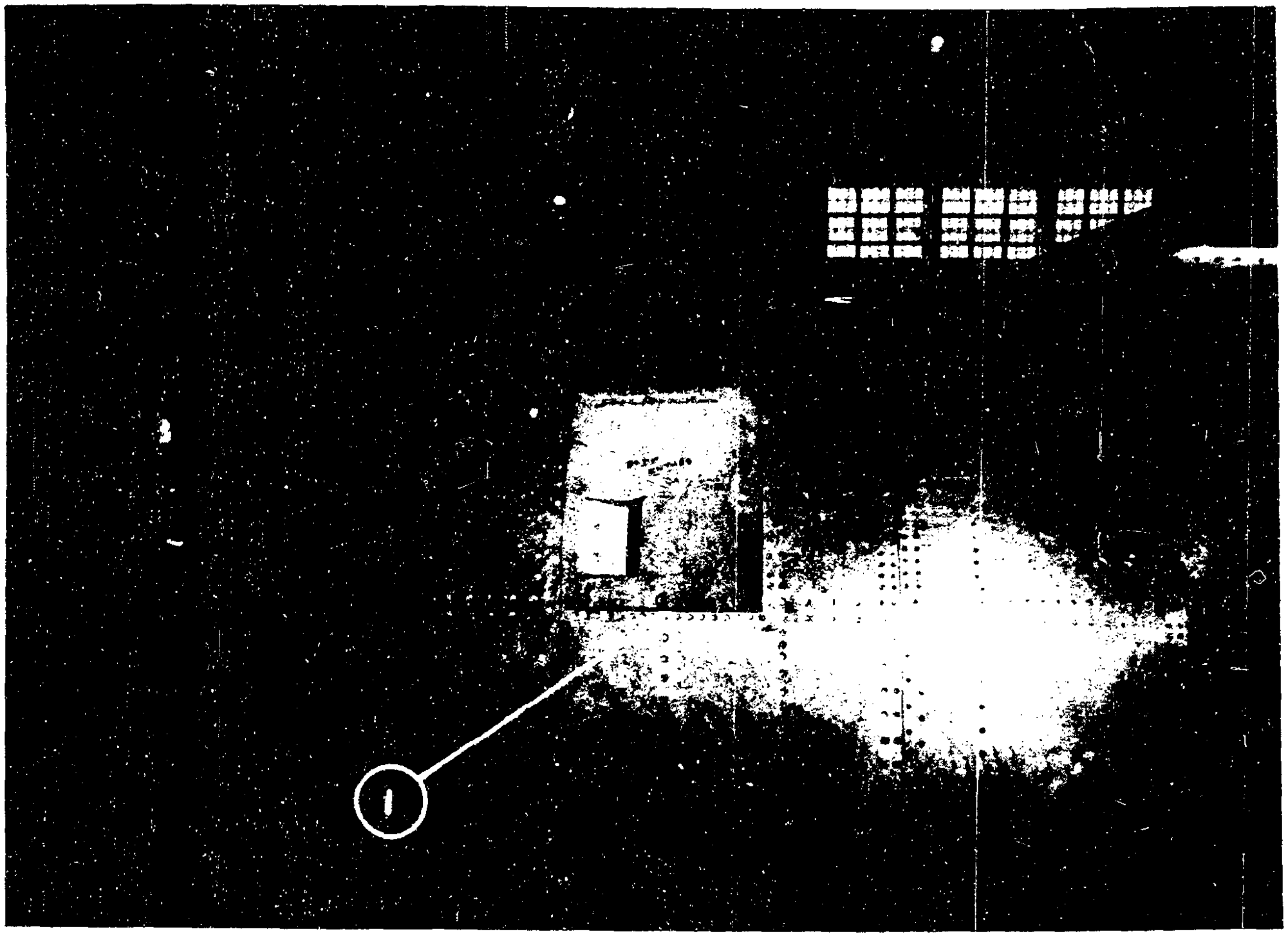
VHF Homing Antenna Sketch F-86 Fuselage

Fig. 10

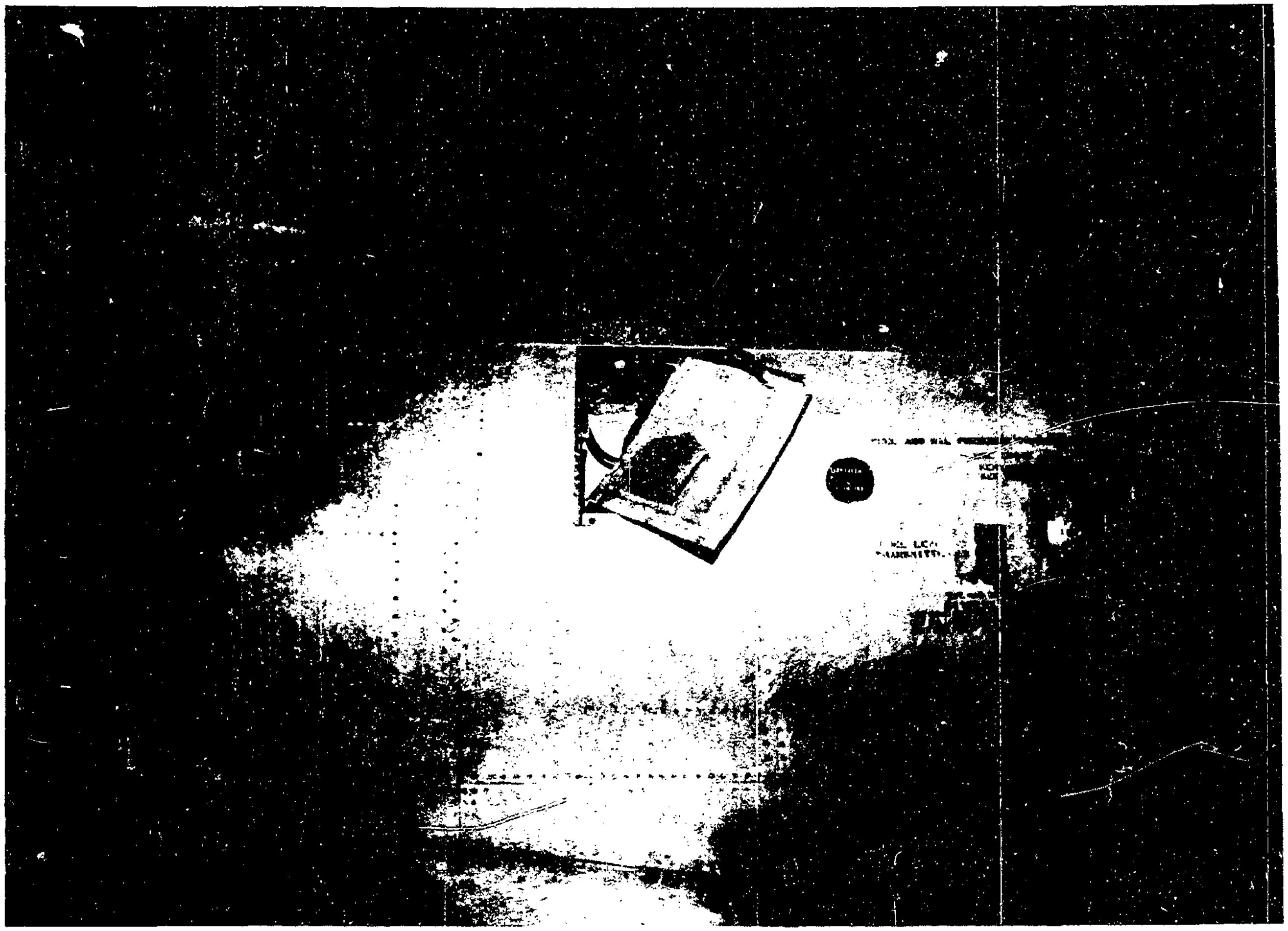


1. Antenna Panel.
INSTALLATION OF VHF FLUSH MOUNTED HOMING ANTENNA ON F-86, 47637, AIRPLANE SHOWING LOCATION AND SIZE OF PANEL.

Fig. 11

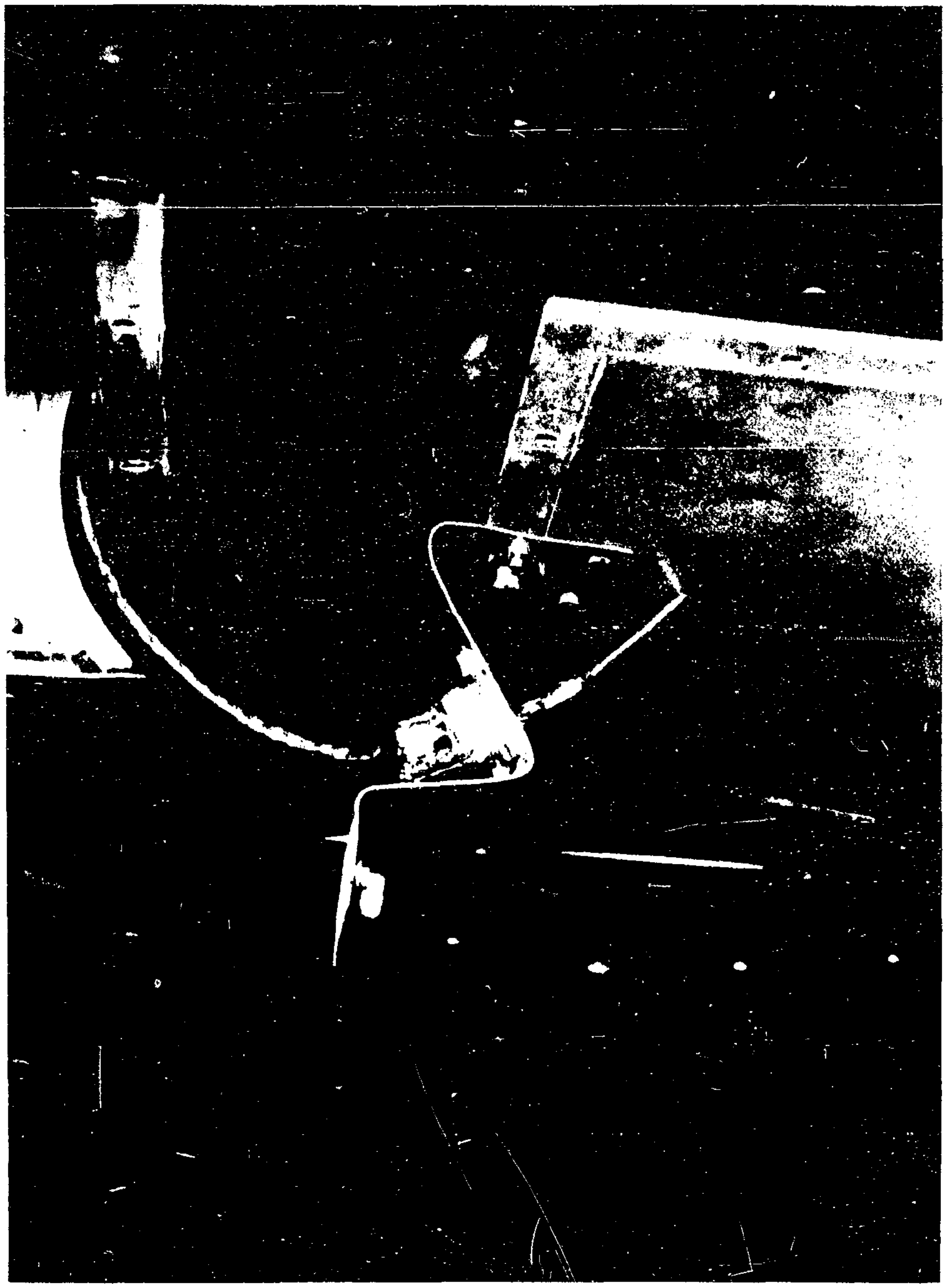


1. Antenna.
INSTALLATION OF VHF FLUSH MOUNTED HOMING ANTENNA INSTALLED IN F-86,47637,AIRPLANE .
(CLOSE-UP VIEW)
Fig. 12



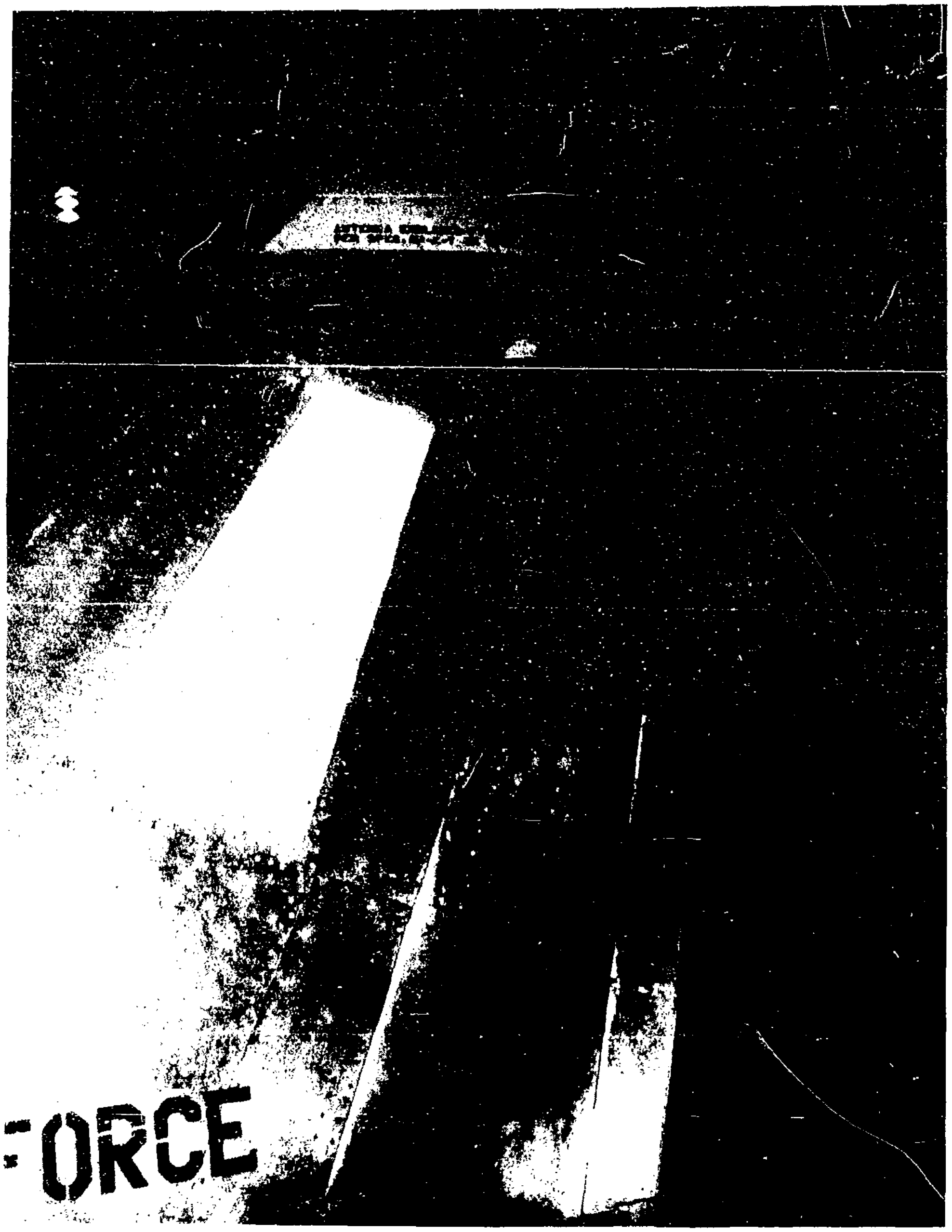
INSTALLATION OF VHF FLUSH MOUNTED HOMING ANTENNA INSTALLED IN F-86, 47637, AIRPLANE.
PANEL PARTIALLY REMOVED FOR INSPECTION.

Fig. 13



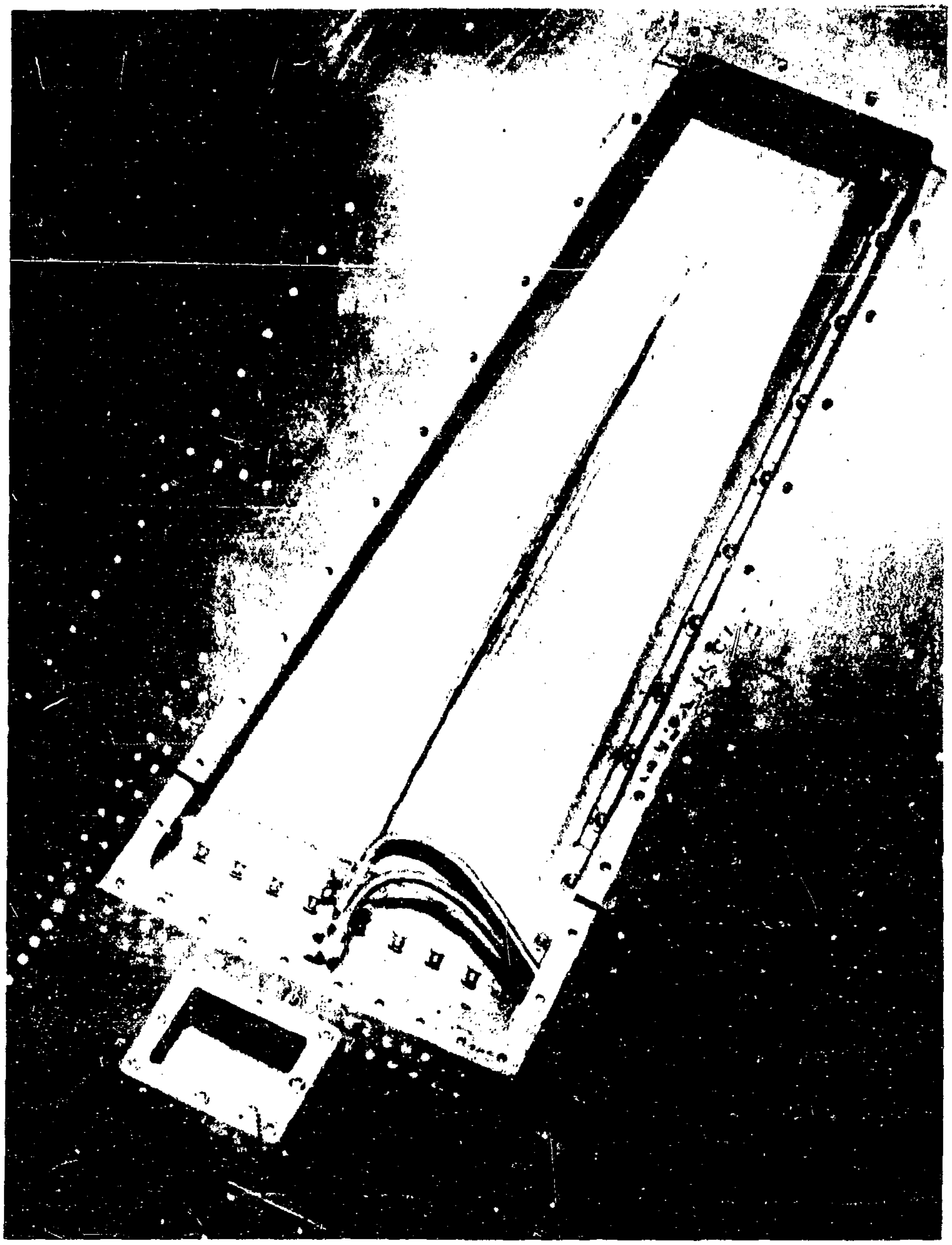
INSTALLATION OF DRAGLESS VHF HOMING ANTENNA (COVER REMOVED);
USED WITH HOMING ADAPTER AN/ARA-8A IN F-82 AIRPLANE.
NOTE: THIS ANTENNA IS UTILIZED WHEN HOMING ADAPTER AN/ARA-8A IS USED WITH RADIO SET AN/ARC-3.

Fig. 14



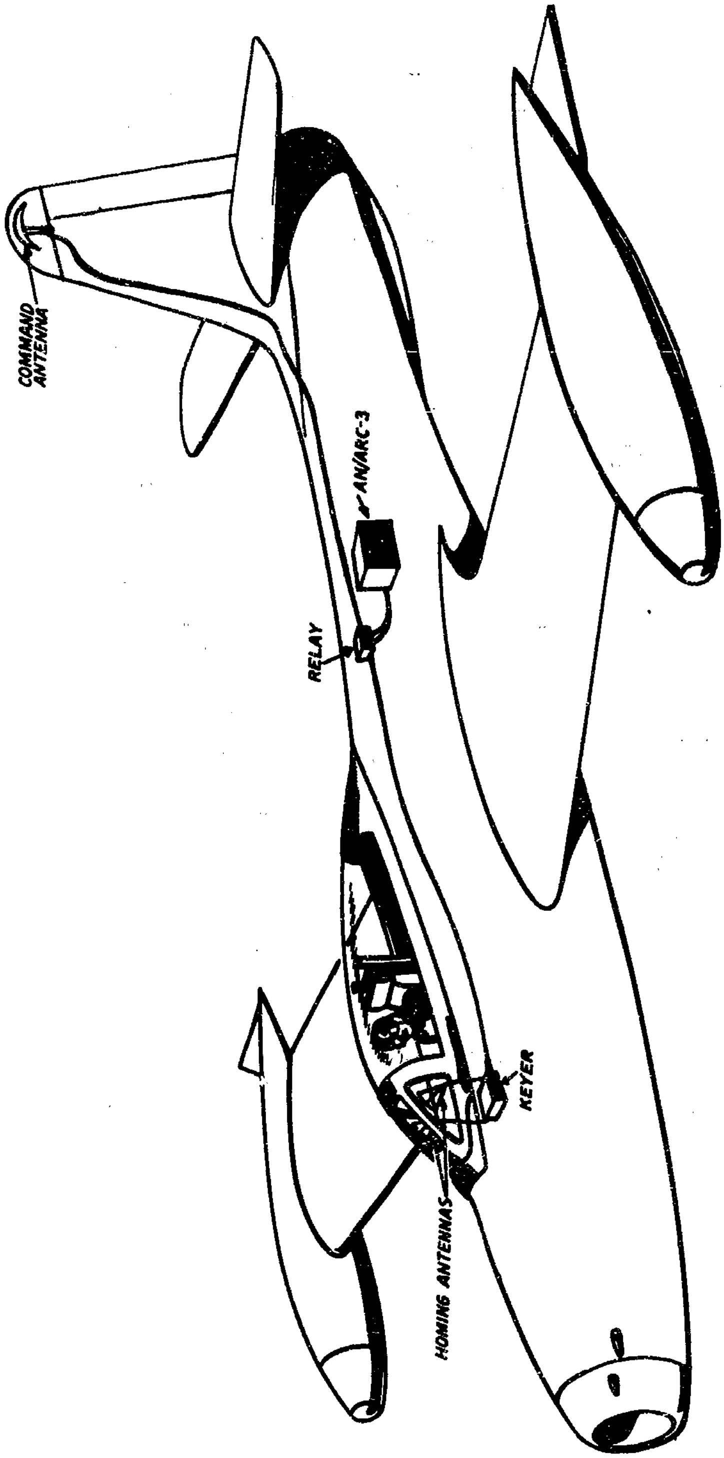
VIEW ILLUSTRATING INSTALLATION OF DRAGLESS VHF COMMAND AND VHF HOMING ANTENNAS IN VERTICAL STABILIZER OF F-86 TYPE AIRCRAFT (PORT VIEW); PART OF RADIO SET AN/ARC-3 AND HOMING ADAPTER AN/ARA-8A, RESPECTIVELY.

Fig. 15



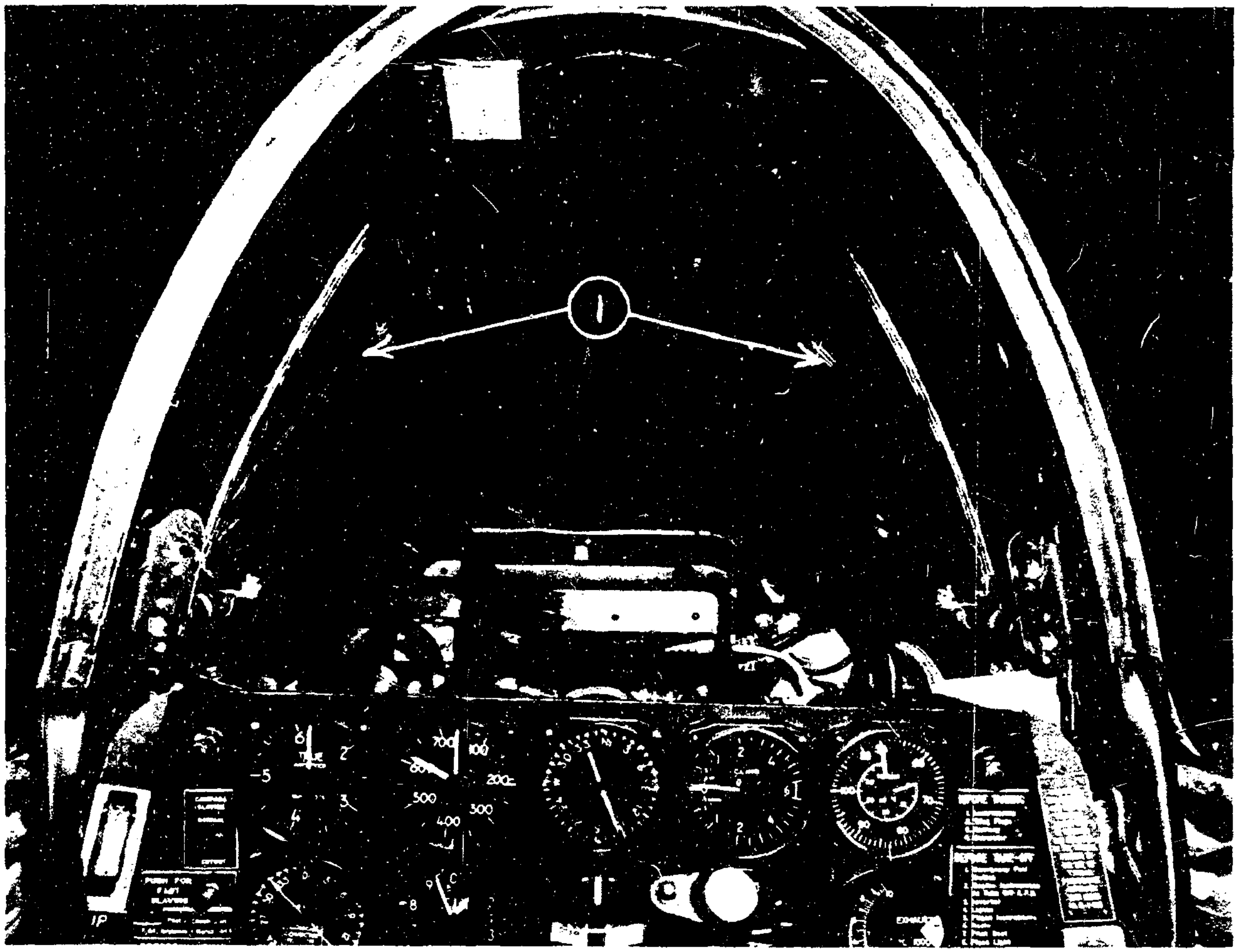
INSTALLATION OF ANTENNA CAVITY AND ONE ANTENNA PANEL FOR EXPERIMENTAL PURPOSES IN F-86 AIRCRAFT

Fig. 16

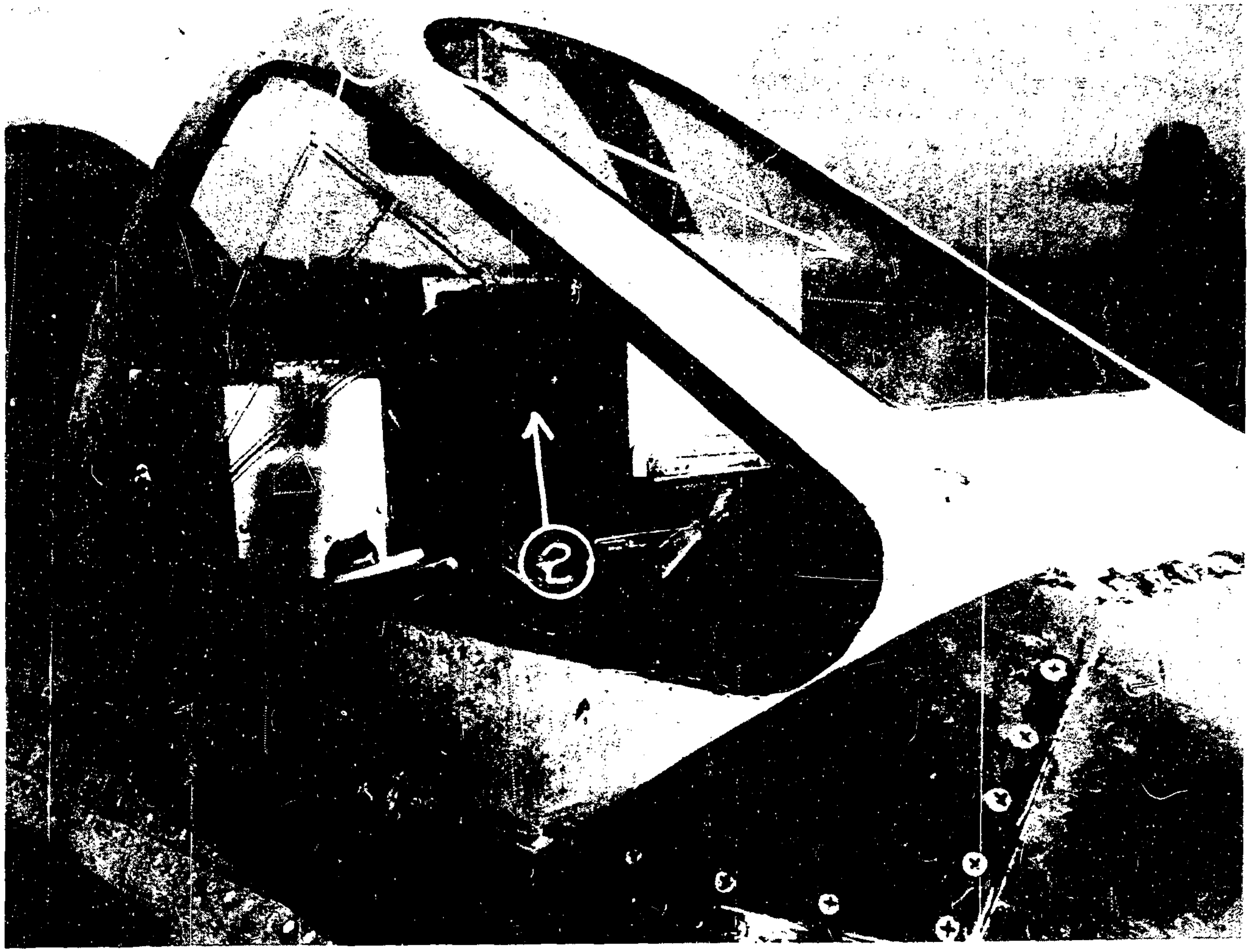


F-84 Canopy VHF HOMING Installation

Fig. 17

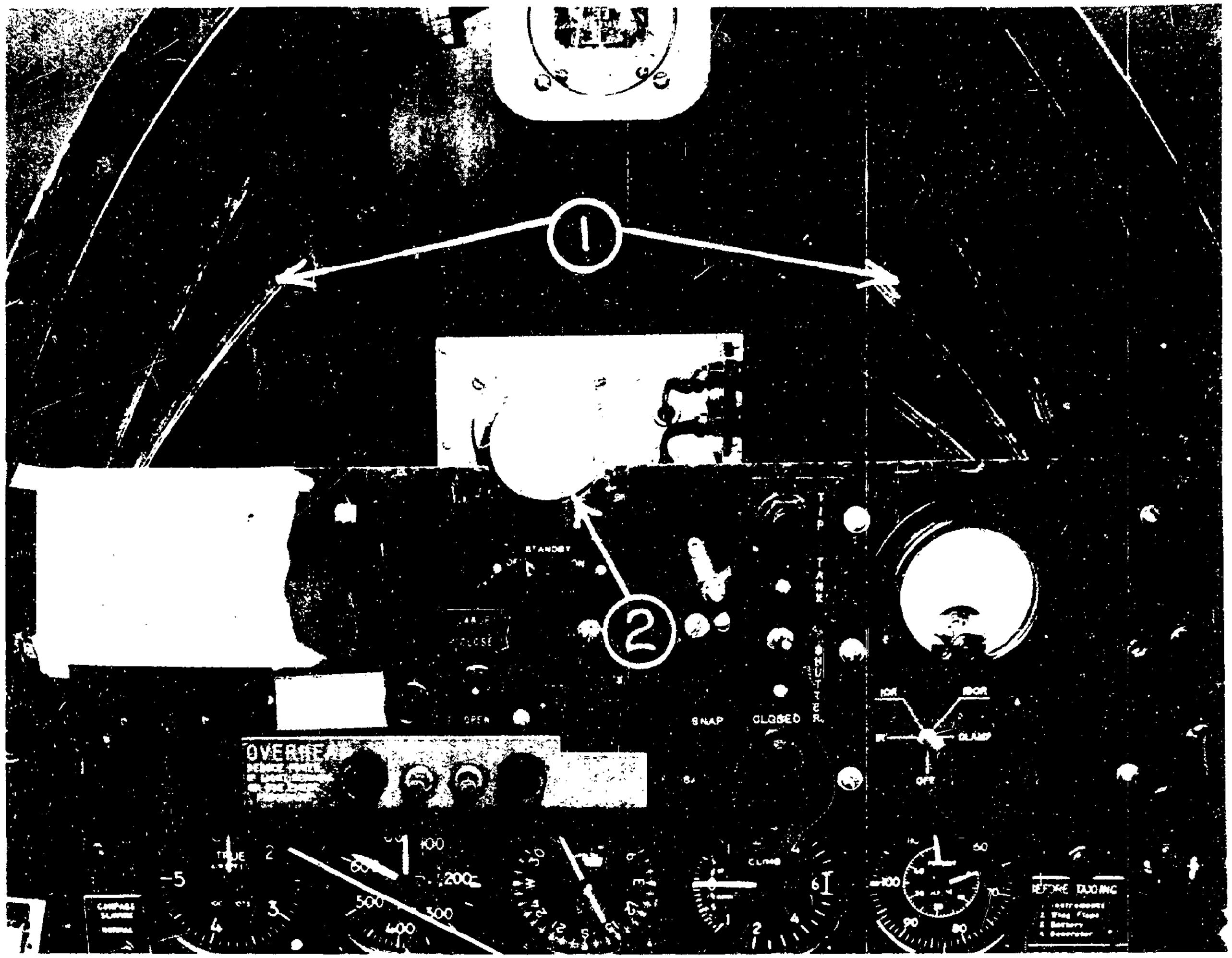


1.Homing Adapter Antennas.
INSTALLATION OF DEVELOPMENTAL FLUSH MOUNTED HOMING ADAPTER ANTENNAS
IN THE FORWARD CANOPY OF F-84G, 511030, AIRPLANE.
Fig. 18



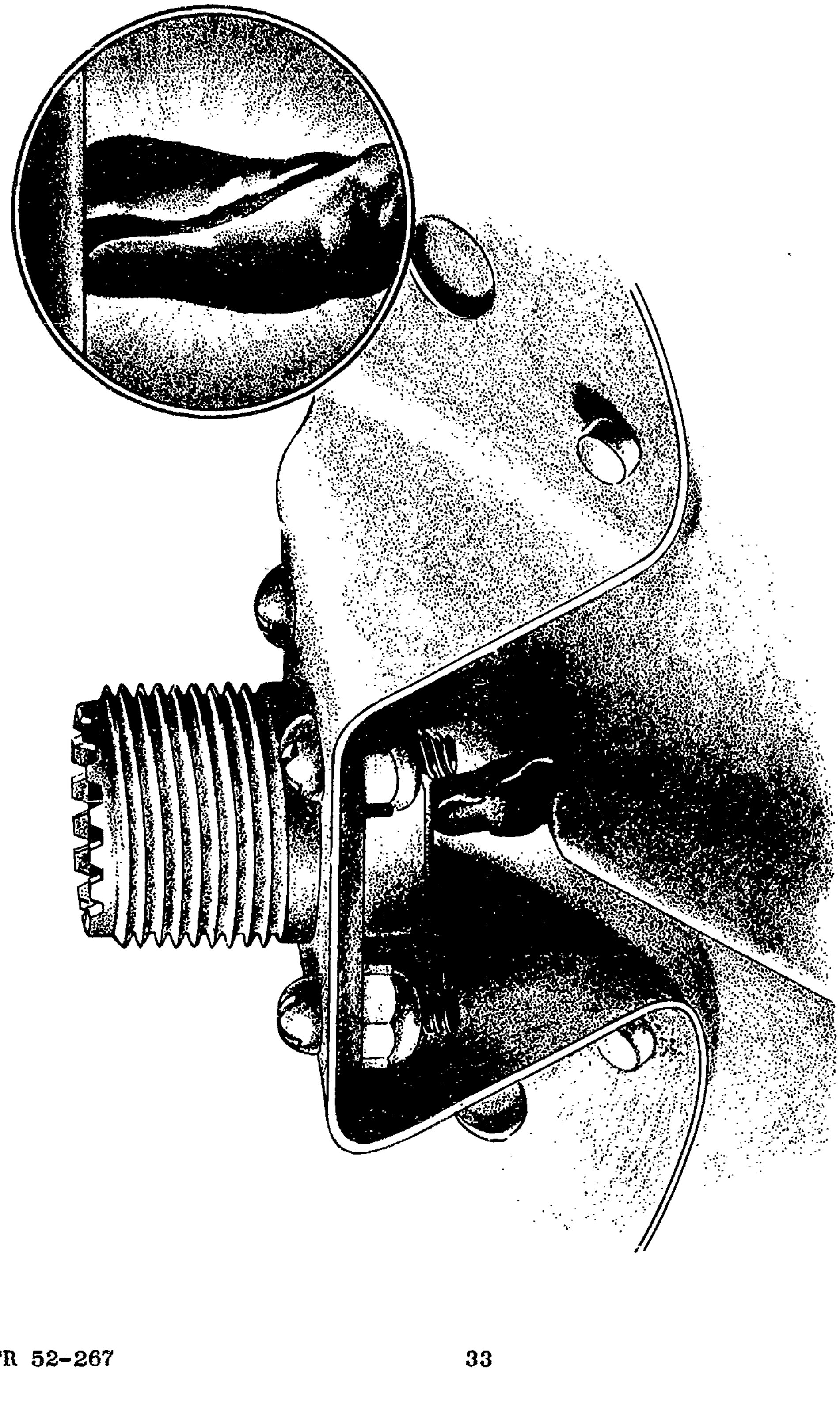
1. Homing Adapter Antennas. 2. Integron Box.
INSTALLATION OF DEVELOPMENTAL FLUSH MOUNTED HOMING ADAPTER ANTENNAS
IN THE FORWARD CANOPY OF F-84G, 511028, AIRPLANE.
SHOWING INTEGRON BOX LOCATED BETWEEN THE ANTENNAS.

Fig. 19



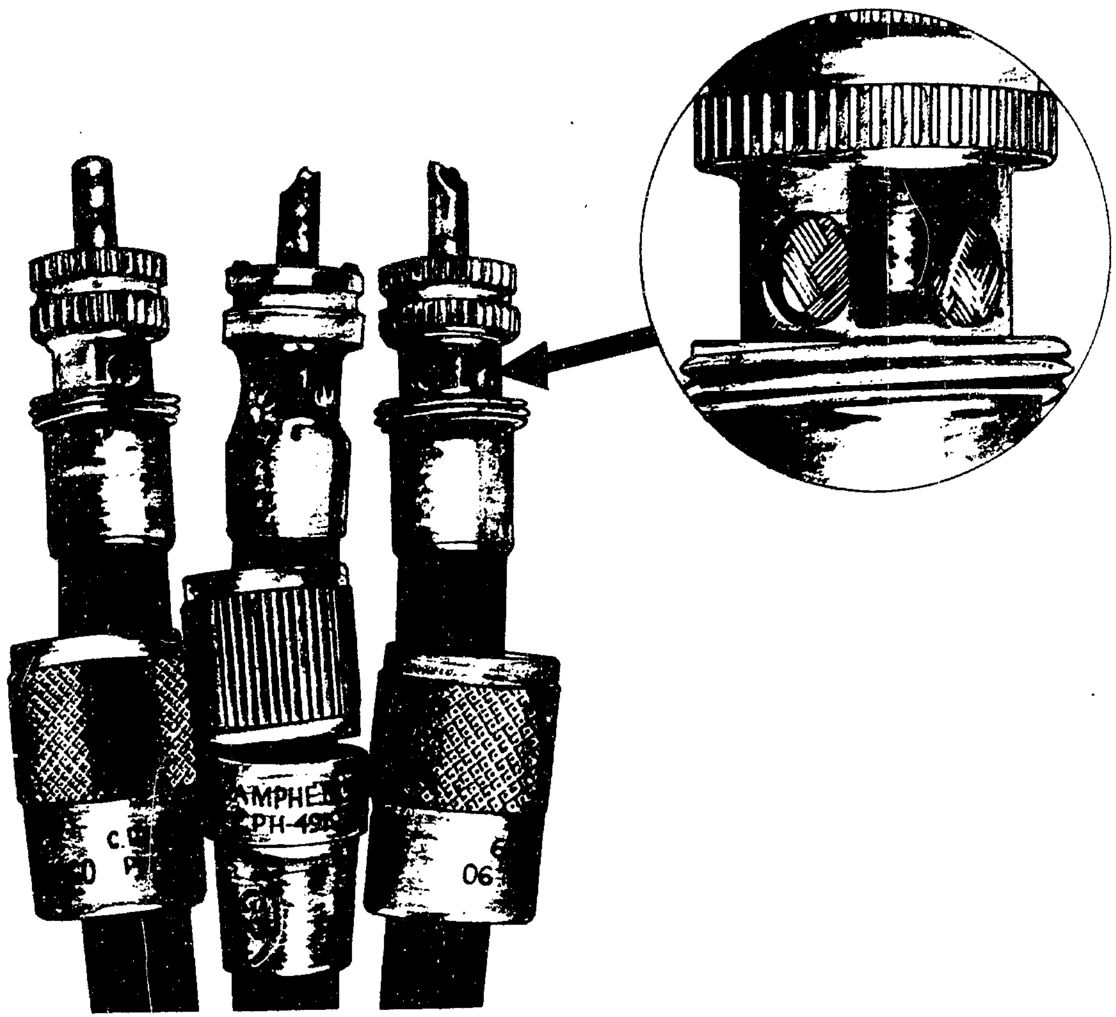
1.Homing Adapter Antennas. 2.Integron Box.
INSTALLATION OF DEVELOPMENTAL FLUSH MOUNTED HOMING ADAPTER ANTENNAS
IN THE FORWARD CANOPY OF F-84G,511028, AIRPLANE.
SHOWING INTEGRON BOX LOCATED BETWEEN THE ANTENNAS.

Fig. 20



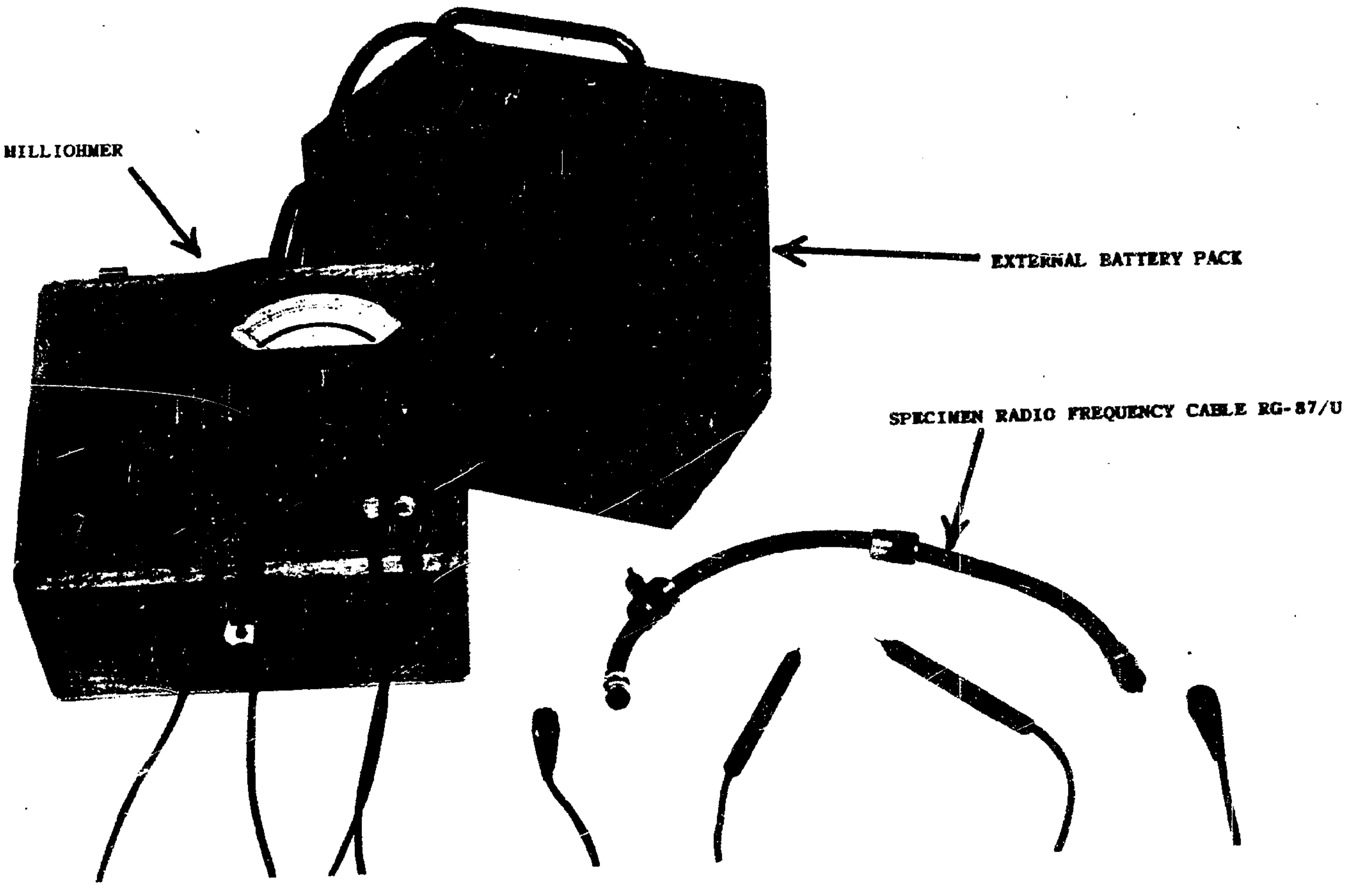
F-80 VHF Homing Antenna Panel (Close-up)

Fig. 21



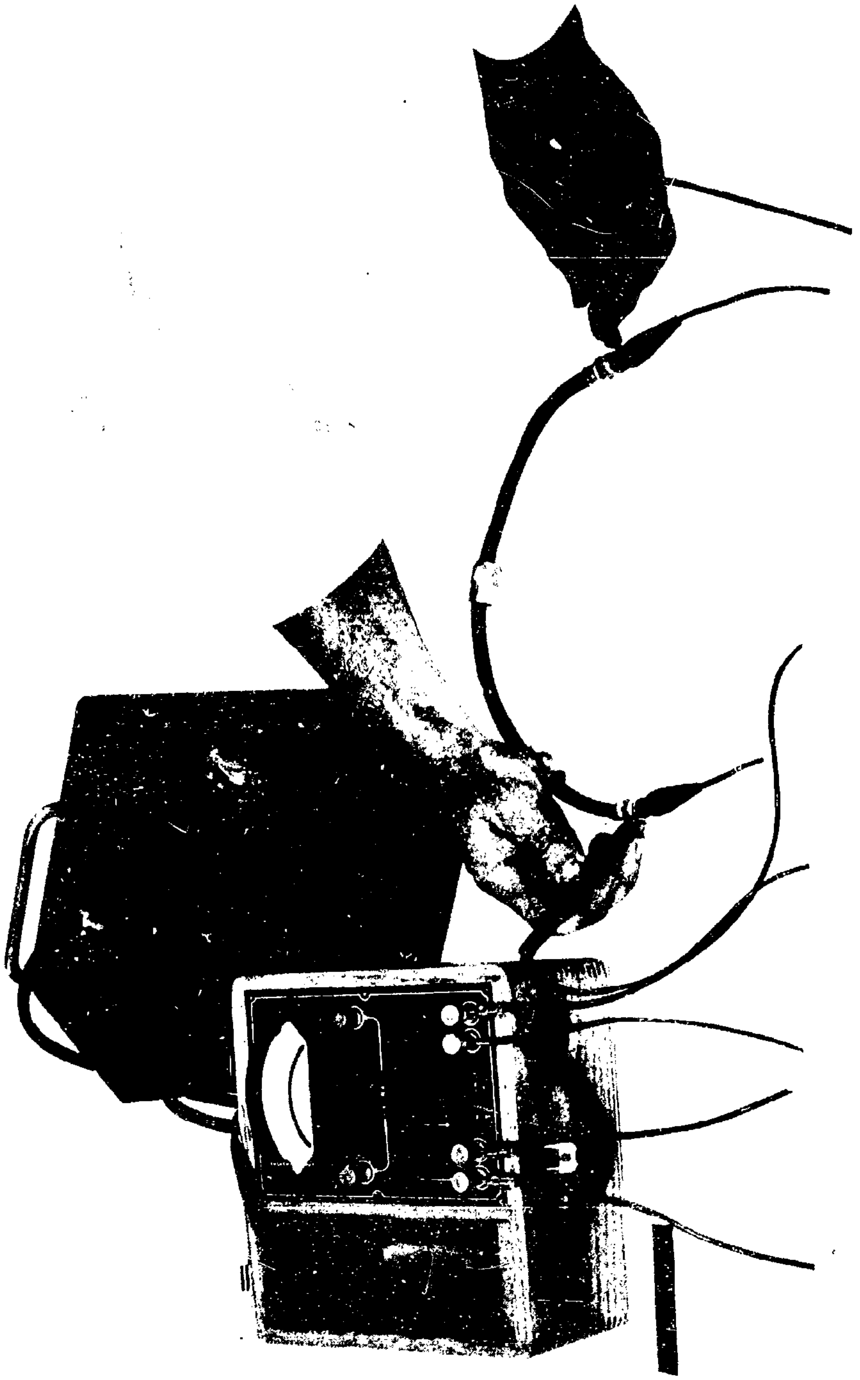
Sketch Showing Examples of Soldering of Standard Cables and Connectors.

Fig. 22

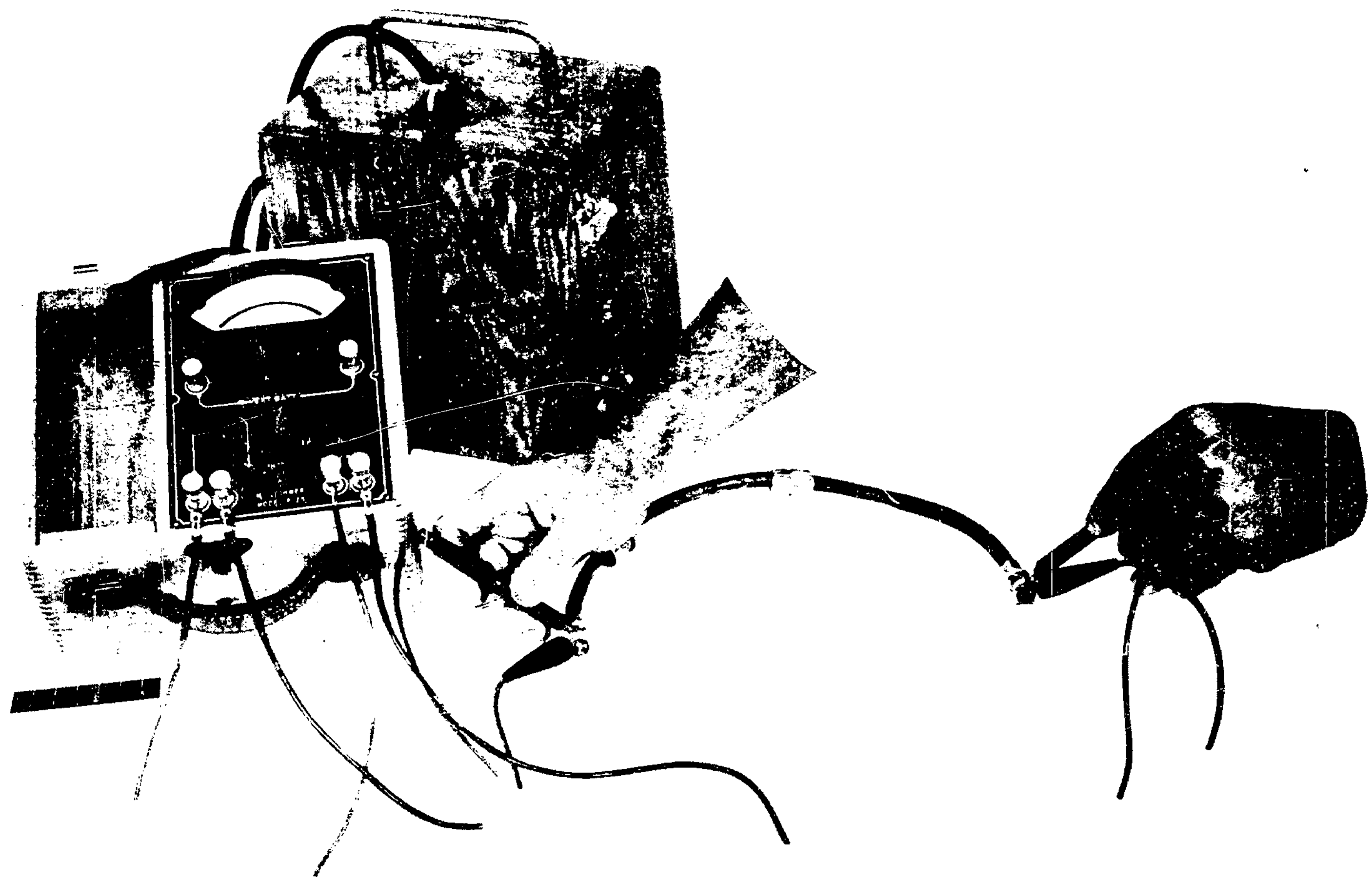


MILLIOHMER (SUPERIOR INSTRUMENT CO. MODEL P-25).

Fig. 23



MILLIOHMER (SUPERIOR INSTRUMENT CO. MODEL P-25)
ILLUSTRATING METHOD OF MEASURING RESISTANCE OF CENTER CONDUCTOR OF A SPECIMEN
OF RADIO FREQUENCY CABLE RG-87/U (.0024 OHM).
Fig. 24



MILLIOHMER (SUPERIOR INSTRUMENT CO. MODEL P-25)
ILLUSTRATING METHOD OF MEASURING RESISTANCE OF SHEATH CONDUCTOR OF A SPECIMEN
OF RADIO FREQUENCY CABLE RG-87/U (.00159 OHM).

Fig. 25

APPENDIX II

INSTALLATION AND SERVICE NOTES

The antenna system or antenna panels should be located in the aircraft in such a fashion and location as to present no additional aerodynamic drag to the aircraft's passage through the atmosphere. The antennas exposed surface should replace the aircraft skin in the area of installation and the transition from metal skin to antenna surface should be as smooth and continuous as possible. Whenever feasible and practical the antenna shall be located so as to result in its exposed surface being parallel to the adjacent slip stream and if it is not possible to locate the antenna in such a position, positive steps shall be taken to protect the antenna's exposed surface from the effects of erosion and aerodynamic pressures. Some of the protective steps to be taken in this event are mentioned in the paragraph titled "Antenna Form Factor."

Fig. 9 pictures the results of a combination of high altitude (low temperature) and rapidly changing pressures on the inside and outside of the aircraft structure at the point where the antenna was installed. You will note from the photograph that a large portion of the surface coat of impregnant has broken loose and blown away. When the panels were fabricated, a surplus of impregnant remained on the surface, aggravating the condition. The breakdown of the surface could have been prevented for a much longer period of time by the increased reinforcement of the panel, a coating of vinyl plastic or rubber, and the proper amount of impregnant permitted to remain on the surface of the panels during manufacture.

Fig. 21 pictures a production VHF Homing Antenna Panel for F-80B aircraft showing another deleterious effect of bulging/buckling action of the panel due to the alternate change of internal and external pressures while in flight. You will note from the picture that the radiating element of the antenna panel has broken loose from the center conductor of the receptacle. This causes unstable or unusable antenna patterns to exist. This condition may be remedied by increasing the reinforcement built into the panel or be relocating the antenna on the aircraft to an area having more stable pressures. The solder junction can be reinforced by first designing a mechanical bond for the connection after which it is then soldered. The antenna end of the coaxial cable attached to the panel should be carefully grounded to the aircraft skin by the shortest (least inductive) strap possible. The junction points between the cable and the strap, and the strap and the aircraft skin should be perfectly clean bare aluminum and securely attached to each other by shakeproof mechanical means. Fig. 21 pictures such a ground connection on an antenna panel showing the grounding contact points carefully cleaned of paint and dirt. The areas of contact on the aircraft skin must also be thoroughly cleaned.

It is important that the fabricators of the phasing cables and/or connecting cables for the antennas use extra care to be assured that all solder connections are well made when the plugs are attached and that small pieces of copper braid or strands of center conductor do not foul when the plugs are placed on the cable ends thereby shorting or partially shorting out the cables. The soldering of the cable sheath to the plug shell is the greatest task and special pains shall be taken in this part of the fabrication. Fig. 22 is an artist's sketch of two poor and one good solder connection. The connecting cables from the antenna panels and/or phasing systems to the homing adapter equipment should at least be the same exact mechanical length to make certain that the attenuation of the cable from each antenna to the receiver is the same. All of these points are important in a balanced antenna system since the average human ear can detect as little as 0.3 db differential in amplitude levels when employing aural homing systems having balanced antenna systems with aurally identifiable lobes. This information is reported on in MCREE-50-12, see Bibliography. A small amount of unbalance in the antenna system can cause a shift of the "on course" and "tail course" from their proper locations with respect to the aircraft fore and aft centerline and may even introduce "false on courses" under certain conditions.

In some installations it is necessary and convenient to locate the homing antenna panels quite some distance apart and also several feet from a central location so that matched (length) cables are required to connect the antennas with the lobe switching keyer - modulator unit. When such a length is required for the cables it is important that the minimum and an identical number and type of bulkhead adapters, and other adapters are used in the makeup of each of the cables. In planning the particular installation the number of cable adapters and plugs and length of the cables connecting the antenna panels to the lobe switches should be kept to a minimum for the following reasons: the coaxial cable attenuates the signal of from 2.5 to 4 db per hundred feet and much more than this when several cable plugs and adapters are made a part of the cables length. In addition the contact resistance between the plugs and adapters cannot always be assumed to be the same and minimum in any or all cases. Also the overall length of the cable connecting the receiver transmitter unit, switching unit and each antenna in turn should be kept to a minimum to reduce to a minimum the system loss thereby resulting in the highest possible overall efficiency (sensitivity).

A greater portion of the troubles arising from these homing installations can be resolved by measuring the DC resistance of discreet portions of the radio frequency system. In connection with the need for cables of equal attenuation and perfectly balanced antennas (efficiency and patternwise) a practical instrument for trouble shooting these and similar installations is the commercial equipment P25 milliohmmeter, as manufactured by the Superior Instrument Company. See Fig. 23. This instrument should be equipped with a "high current" external battery source in preference to the battery supplied with the instrument.

D. C. Resistances of the RF Cable Elements of Most Used R F Cable Types.

Length		11 ft 5 in	1 inch	1 ft.	Unit
RG87/U Cable	Center	0.0218	0.00016	0.00192	Ohms
	Sheath	0.0162	0.00012	0.00144	Ohms
RG 8/U	Center	0.0215	0.000157	0.00188	Ohms
	Sheath	0.0133	0.000097	0.00116	Ohms

The approximate resistance between the antenna receptacle shell and ground point of the aircraft skin immediately adjacent to the ground screw should be in the order of 0.001 ohms. This resistance measurement should be the same for each antenna panel of a system. Fig. 24 and Fig. 25 depict the measuring of the resistances of an RF cable specimen which shows the effectiveness of contact (solder or mechanical) between the cable plug center conductor and the cable center conductor and the plug sheath and the cable sheath conductor. The measurements of cables having the UG/-- type cable plugs are made in the same way as those shown using the old UHF plugs PL259A. The D.C. resistance between the center conductor and grounded shell of the RF connector on each antenna panel should be equal and is usually found to be in excess of 10 megohms. This measurement can be made using a reliable vacuum tube voltmeter or megohmmeter (TS352).

If for reasons of precipitation static interference it is desired to coat the panels with a conducting paint or coating, a coating of as low as 500,000 ohms/square should not affect the operation of the panel as an antenna. To preserve an efficiency balance between the antennas of a system the coating of each panel should have as nearly the same resistance (ohms/square) as it is possible to apply. This approximate equivalence can be measured while the panels are installed on the aircraft by carefully measuring the capacitance between the center conductor and the grounded shell of the RF receptacle of the antenna panel with an appropriate VHF Q meter. For further information on the application and measurement of anti-precipitation static coatings see U. S. Naval Test Center Report TED No. PTR-EL-582, dated 1 Nov 1951 titled "Determination of Allowable Resistivities for Antenna Canopies."

In jet aircraft antenna installations, made aft of the cockpit, only RG87/U cable shall be employed as RF connecting cable and antenna phasing cable.